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Cover: Panther chameleon, *Furcifer pardalis*. Photograph by Caitlin Monesmith (see “About This Month’s Cover” on page 52).

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Stretching the Truth: The Elastic Properties of the Body and Skin of a Giant Snake

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Introduction

The elongated body of the snake is in many respects an outstanding and unique creation of evolution. Much research has been done studying the anatomy of the snake, but there remain some basic anatomical and physiological features yet to be investigated.

The spines of snakes may consist of as many as 400 tightly assembled vertebrae, with a ball-and-socket type of articular joint, the intervertebral joint, between each pair of adjoining vertebrae. The intervertebral joint is made up of a condyle (the “ball”) on the posterior surface of a vertebra that is nested into a cotyle (the “socket”) on the anterior surface of the next vertebra in the sequence. Each condyle and cotyle is covered with a thin layer of cartilage. The thickness of these layers keeps the vertebrae from being compressed together, and the elastic properties of the cartilage cushion axial movements (Gasc, 1974). The intervertebral joints are surrounded with strong ligaments and thick spinal muscle packages that prevent the vertebrae from being pulled apart. Some literature reports indicate that the length of the body of a snake might be elastic along the intervertebral joints (Blouin-Demers, 2003; Cundall et al., 2016; Lock, 2021), and thus can stretch and contract, yielding variable measurements. However, we are not aware of any research investigating and quantifying the potential for the elongation or contraction of the snake vertebral column.

The ultimate goal of our investigation has been to determine a correct maximum length record for the reticulated python (*Malayopython reticulatus*). At this time the reticulated python is considered by most authorities to be the longest extant snake species.

Over the history of the species, first described in 1801 by Johann Schneider, there have been several methods used to measure the lengths of large specimens. We will publish our efforts and findings in upcoming issues of this journal. However, we reasoned that before accepting any determination of the length of the reticulated python, or indeed any snake, it is essential to acquire detailed knowledge about the elasticity of snakes’ bodies, both living and dead.

The lengths of some potential record specimens of reticulated pythons have been based on skeletons. A dried and cleaned skeleton is significantly shorter than the original body length of the live snake. To make an accurate estimation about the length of these animals in life, it is necessary to know this shrinking factor.

Likewise, many record lengths have been based on skins. So far as we could determine, the individual scales of a snake are relatively inelastic; an individual scale does not significantly shrink or stretch when the skin of a snake changes in length or width. But the skin of a snake is extremely elastic in all directions due to the folding of the interstitial skin that surrounds each scale. The interstitial skin allows considerable stretching,

and by elastic recoil a return to the resting state (Close and Cundall, 2014).

Even though it is well accepted that the hide of a skinned snake may stretch to a length that is considerably longer than the actual snake, most reports are anecdotal. Murphy and Crutchfield (2019) write that it is difficult to remove a skin without stretching it about 20%. Jacobson (1936) states that snakeskin can be stretched in length and width by at least 25%. Jones (1997) states that rattlesnake skins may stretch 30–50%, and Auliya (2006) states that python skins stretch approximately 30%.

Moreover, there is no information on how to determine how much a skin has been stretched after removal from the snake body. When the reported lengths of giant snakes are based upon skin lengths, it is essential to have information on this factor based on careful quantitative investigation.

To obtain data that will contribute to answer these questions, we performed several experiments with the dead body of a large reticulated python, *Malayopython reticulatus*. We compared those results to results achieved by treating the body of a rat-snake (*Pantherophis obsoletus* complex) in a similar manner. Additionally, we include comparisons of data from the existing literature and from two well-documented specimens of reticulated pythons in museums.

Examination of a large *Malayopython reticulatus*

A female reticulated python that died in 2008 in a zoo in Switzerland was used for the experiments (Figures 1 and 2). At death it was bagged in plastic and frozen for five years before the actual experiments were conducted, between July and August 2013. All measurements were taken with measuring sticks and non-stretchable strings by one of the authors (JPE) to provide consistency. Each measurement was taken at least three times to confirm high accuracy, and the mean values are provided to the

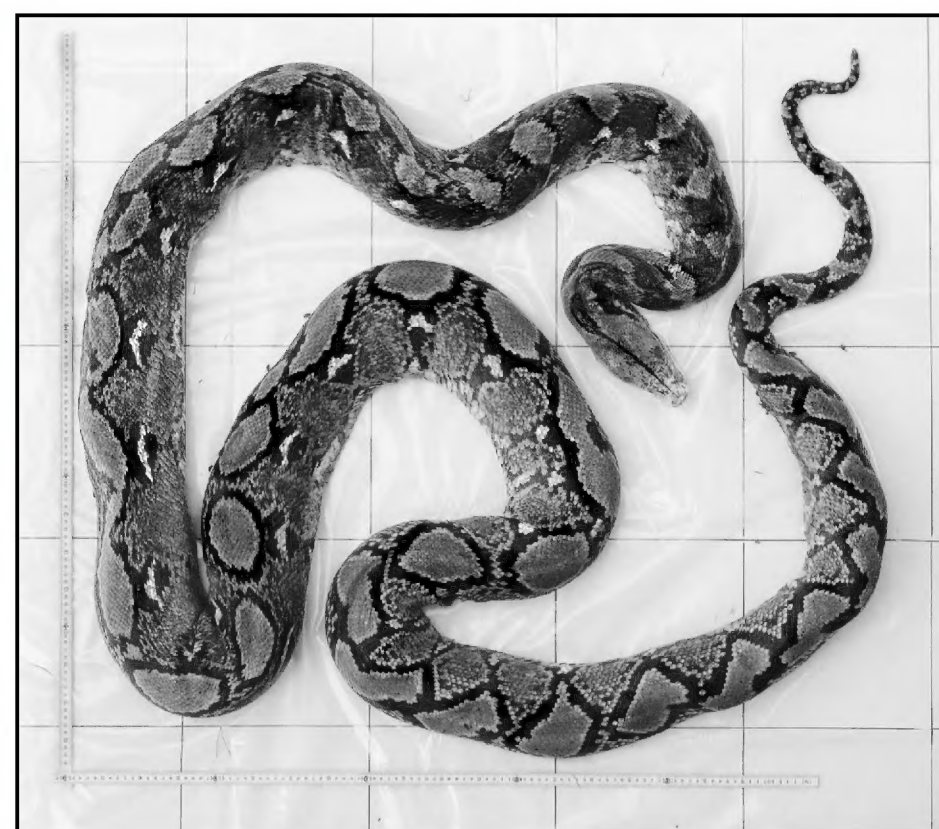


Figure 1. The specimen used in the experiment, freshly thawed.



Figure 2. Dr. Ehram (left) and his assistants hold the freshly-thawed reticulated python to give some proportion to the size of the snake. They stand in front of a grid of .5-m squares.

nearest centimeter. No deviation greater than 1 cm ever occurred in any of the sets of measurements. Each step of the experiment was photographed on a metric grid—a pattern of squares with sides measuring 0.25 m; images made to illustrate comparisons between steps were taken from 5 m above the grid (see Table 1).

Step 1. The body of the reticulated python weighed 32 kg. To thaw, the frozen carcass was exposed to a temperature of 25°C for 1.5 days. Rigor mortis was present but moderate, and it was possible to relax and mostly straighten the body, which did however retain kinks in a few places along its length. The body was placed on a long pattern of .25-m squares, but straight-line measurement was not possible. The snake was measured by placing a string along the dorsum above the vertebral column from the tip of the nose to the tip of the tail. The freshly thawed snake was determined to have a total length of 5.87 m; we consider this original body length as the “zero-state” length.

Step 2. To prepare for our attempt to stretch the body of the python, a grid of .25-m squares was placed on top of a 7.2-m board. The board was solidly anchored to the ground at each end with strong carpentry clamps driven into the ground. The body of the python was positioned lengthwise on the grid. A looped fastening strap was tightly affixed with cable ties to the neck 17 cm from the tip of the snout (Figure 3), and a second strap was similarly affixed 10 cm from the end of the tail. The loops extended about 2 m beyond the head and tail and were pulled over the columns of the anchoring carpentry clamps. Each loop was grasped by hand, and stretching force was manually provided from both sides. Our attempts to stretch the snake continued until more than just moderate force was required to lengthen the snake. At this point the total length of the snake was increased by 3.6% to 6.08 m. This degree of stretching might have

been possible simply by hands holding the snake on the neck and tail. At this point the force necessary to increase the length increased exponentially. Our attempts to maximally stretch the body of the snake resulted in a total length of 6.39 m, an increase in length of 8.9%.

Step 3. Twelve hours after the stretching of Step 2, we repeated the stretching experiment. This time the body was stretched to a maximum total length of 6.48 m. This is a 10.4% increase from the original total length of the freshly thawed snake.

Note: We observed that after each of the two stretching sessions the body shrank to nearly its zero-state length of 5.87 m. After 1.5 hours of continuous stretching for Step 2, the length of the body shrank to 6.09 m only 15 minutes after stretch efforts ceased; 12 hours later it measured 5.92 m. Twenty hours after the second stretching session of Step 3, the body measured 5.93 m, a 1.0% increase in length.

Step 4. The snake was skinned four days after thawing. The careful skinning was performed by a scalpel, and took 14 hours

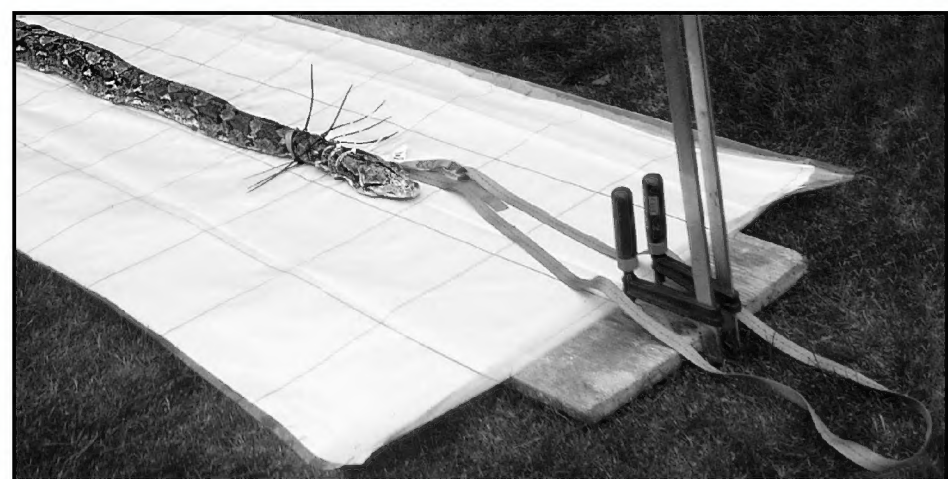
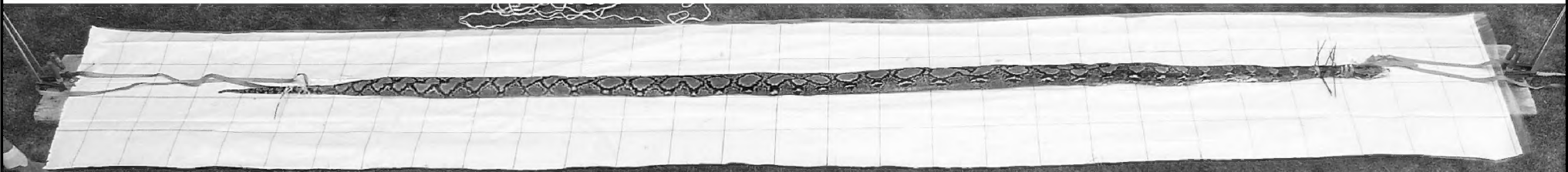
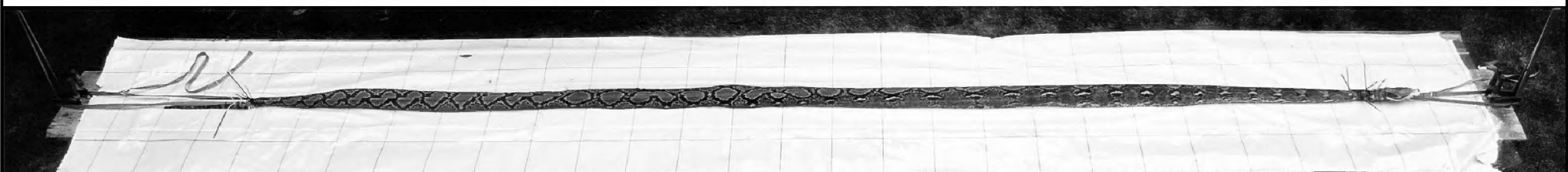
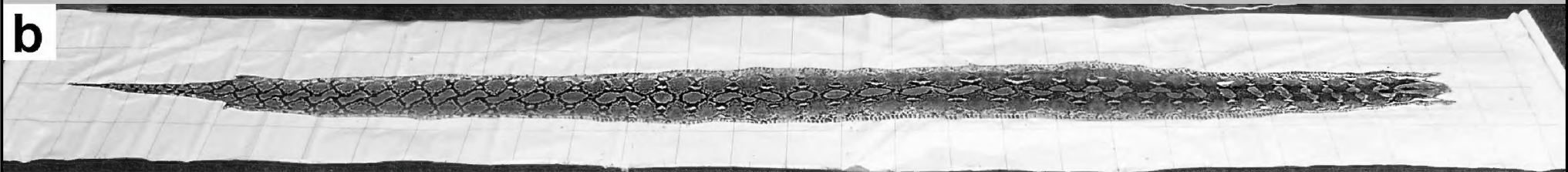
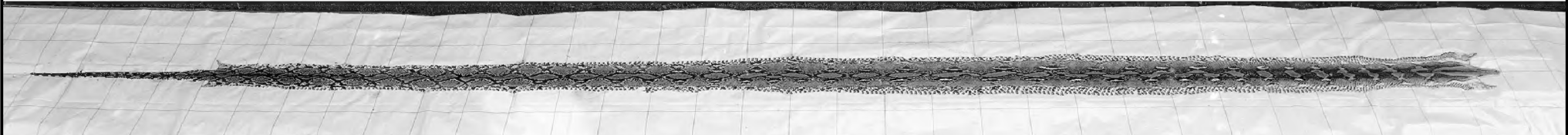


Figure 3. This is the apparatus used to stretch the body of the snake. A similar setup is connected to the tail of the snake.

Table 1. Photographic documentation of the experimental stretching of a large *Malayopython reticulatus* (see text for details).


Step 1. The freshly thawed body of the python positioned on the grid of .25-m squares, relaxed and relatively straight.

Step 2. The nearly straight body of the python, having returned close to its zero-state length 15 minutes after having been stretched in length 3.6% by moderate force applied to the loop fastening straps.

Step 3. The body of the python at maximal stretching. The body length has increased 10.4% from the zero-state length due to the increased force used for this stretching. It then took 20 hours to regain the zero-state.


Step 4. a) The freshly skinned body of the python; b) The freshly removed skin from the python.

Step 6. The maximally stretched skin, now nailed to a board. At this step the length of the skin is 8.00 m, a 36.3% increase from the zero-state length of the body of the snake.

to complete. Every effort was made to avoid any stretching of the length of the skin. After this procedure, the skin still had some fascia along the back. The skin was gently laid out on the grid without stretching, inner side down. It measured 6.75 m, a 15.0% increase from the original length of the body. No interstitial skin between scales was observed anywhere on the skin (see row 2 of Table 2).

The skinned body was measured. It now had a length of 6.04 m. Why the body length increased by 2.9% from its zero-state length might be due to a general relaxing of the body, but contributing factors could include the strong “massage” of the intervertebral joints during the skinning process, the lack of the slight tension of the skin, and the progressing decomposition.

Step 5. The freshly removed skin was frozen for a week, then

thawed, and the remaining fascia along the back of the skin was removed. We then measured the skin at 7.09 m. After manually stretching and nailing it on a board, the skin measured 7.38 m (see row 3 of Table 2), an increase in length from the zero-state length of the body of 25.7%. We observed that at this stage the skin appeared essentially unstretched with few visible interstitial gaps between the scales.

Then we stretched the skin further by the following technique: Seven 1-m square boards were placed in a row. The skin was placed on the boards and the skin areas in the midsections of the boards were temporary fixed to the boards. Then the gaps between the 1-m boards were expanded by additionally introducing small boards in between. The resulting stretched skin was transferred and nailed down on the large mainboard with the grid. The stretched skin was 7.67 m, an increase in length of 30.7% from the zero-state length. At this size, the anterior part of the skin appeared to be quite stretched and subject to rupture. However, the posterior part still had a thick layer of dermis and was very hard to stretch.

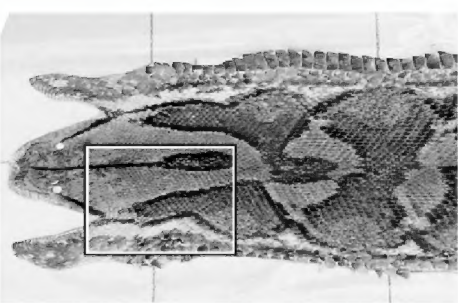
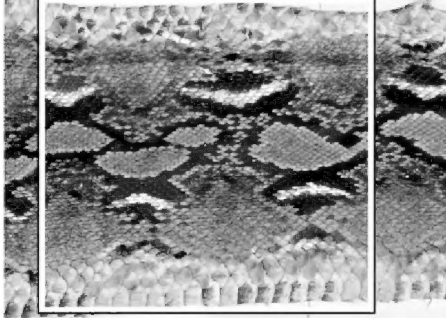
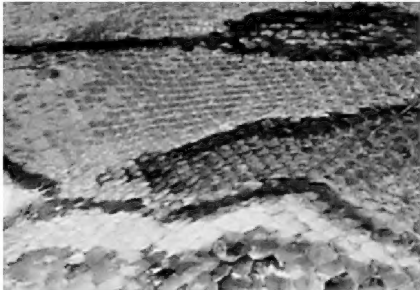
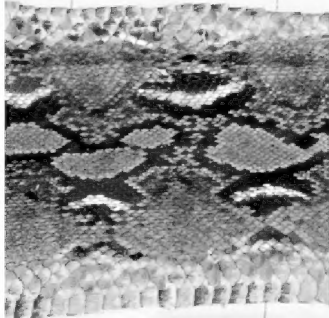
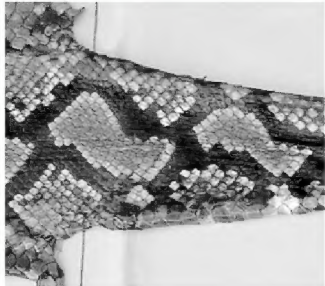
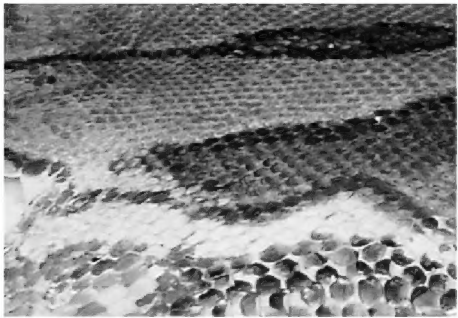
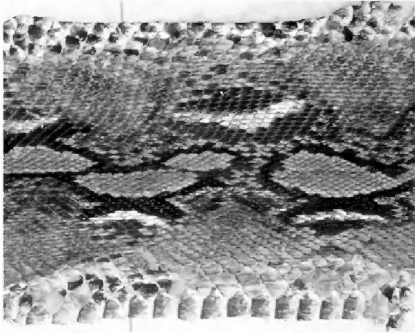
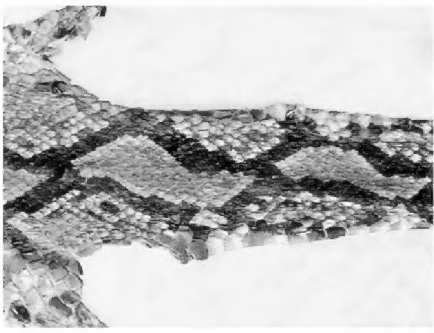
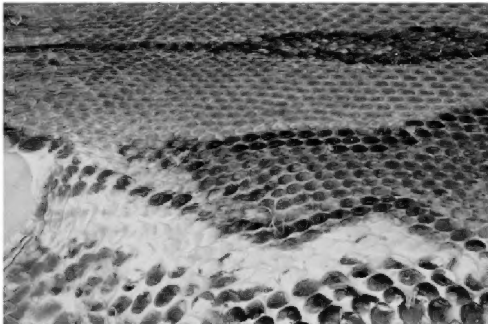
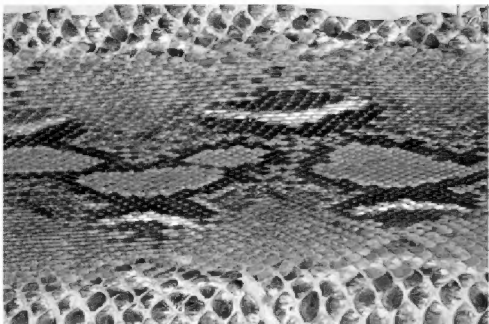
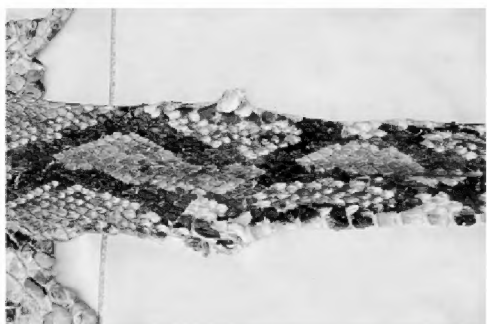
Step 6. Continuation of the stretching at that time was not possible and the skin was again frozen. After the skin was thawed, work commenced using serrated steak knives to remove

the remaining dermis, a procedure that took 24 hours. The stretching procedure was repeated to the now uniformly thin skin, and we were then able to stretch the skin to 8.00 m (see row 4 of Table 2). This is a 36.3% increase from the original body length. At this state, the stretching procedure began to demolish the skin along the ventral and paraventral areas, with tears appearing where earlier we had created small holes with nails. This prevented us from further stretching the skin. At this state of maximum stretch, the scales were separated, and interstitial skin was visible throughout most of the skin.

Note: The scales themselves do not appear to stretch, at least not to any degree we could measure. This is further evidenced by our observation that the stratum corneum, the external keratinous layer of the epidermis that covers the surface of each scale, remained firmly attached to most scales during and after stretching.

Step 7. To prepare the skeleton, the flesh was rudimentarily removed from the carcass. Lengths of the spine and ribs were cut into sections. The sections were then cleaned to bones in a bath of 55–60°C warm Enzyrim (Bauer Handels GmbH, Switzerland). This mixture of enzymes does not damage bones in any way, and even the smallest structures stay intact. After 19 days of drying, the skeleton was mounted by putting a wire through the

Table 2. Photographic documentation of the process of stretching the skin of a large *Malayopython reticulatus* (see text for details).

In this row are pictured lengths of the unstretched skin, from the anterior, midbody, and posterior portions of the total length of the skin, photographed about 30 minutes after removal from the snake. The indicated areas are detailed in the rows below.	 the anterior portion of skin	 the midbody portion of skin	 the posterior length of skin
In this row are images of portions of the unstretched skin taken of the areas detailed in the image above. At this time the total length of the skin was 6.75 m.	 anterior — unstretched	 midbody — unstretched	 posterior — unstretched
In this row are images of portions of the skin taken after the first stretching of the skin. At this time the total length of the skin was 7.38 m.	 anterior — first stretch	 midbody — first stretch	 posterior — first stretch
In this row are images of portions of the skin taken after the second, maximum, stretching of the skin. At this time the total length of the skin was 8.00 m.	 anterior — maximum stretch	 midbody — maximum stretch	 posterior — maximum stretch

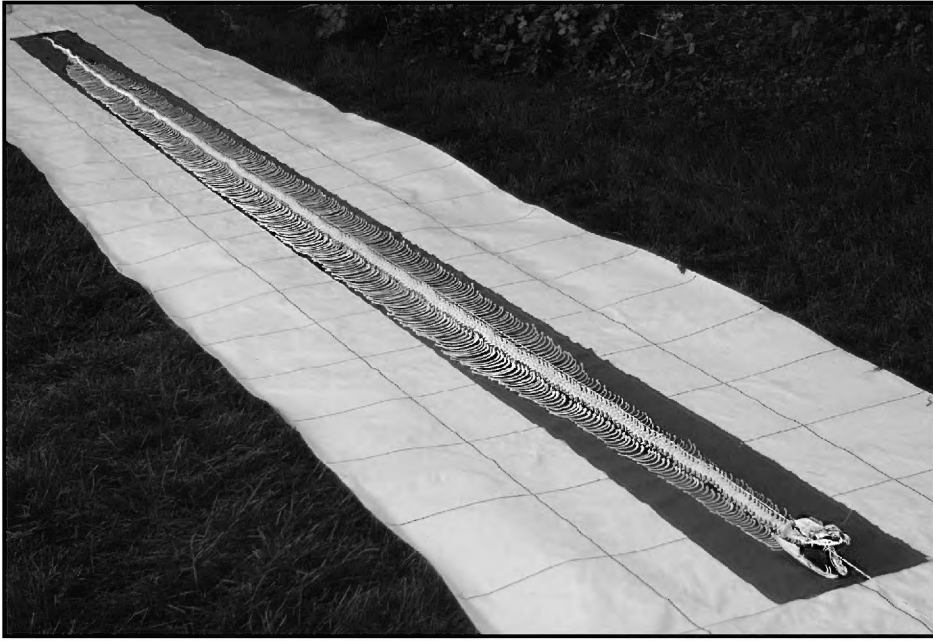


Figure 4. This is the assembled skeleton of the python, positioned on the grid of .25-m squares.

spinal canals of the vertebrae in each section. The sections were then wired together. The final, very tight, reassembled vertebral column and skull measured 5.61 m (Figure 4). The length of the skeleton was 4.4% less than the zero-state length of the snake.

Examination of a *Pantherophis*

A dead specimen of a ratsnake (*Pantherophis obsoletus* complex) was examined in July 2013. This specimen had been frozen for one year. It was thawed at 25°C for 24 hours. The experiment is illustrated in Figure 5.

The zero-state length of the snake was 1.48 m. The snake was stretched with loops affixed to the anterior neck and tail of the snake. The stretched length of the body of the snake was 1.59 m. This is a 7% increase from the original length. After stretching, and even after skinning, the total body length returned to the zero-state length. The carefully removed skin measured 1.70 m, 15% more than the original body length. During further stretching, the skin tore in its more fragile anterior section. At this point it measured 2.00 m, a 35% increase over the total body length; there were noticeable interstitial spaces present between the scales.

Data from museum specimens of two large *Malayopython reticulatus*

We were fortunate to obtain the measured lengths of the original body and the skeleton of two giant reticulated pythons well documented and preserved in museums. As we learned during our investigations, such data are rare.

One massive skeletonized specimen (ZMUC R5418) is in the Natural History Museum of Denmark, Copenhagen, and is currently on display (Figure 6). The skeleton was kindly examined in 2012 by Mogens Andersen, the collection manager of herpetology and mammology. The detailed measurements can be

found in Table 3. According to the museum catalogue, the measurements of the original body were taken in 1917 as the newly dead animal was received at the museum. This specimen was dried in a straight position, and the vertebrae were never taken apart; the length of the skeleton is 3.4% shorter than the total body length. However, it is possible that the tip of the tail is missing, and that would affect the small percentage of shortening.

The skeleton of the second large specimen is on display at the Museum of Natural History Basel [Switzerland], and it is displayed over a cast made from the body of that impressive giant snake (Figure 7). It was examined in 2012 by one of the authors (JPE) with the permission and assistance of curator Dr. Raffael Winkler. According to the catalogue entry, the original body length was taken from the freshly dead specimen at its arrival. In fact, a measurement of the cast of the snake is in agreement with the recorded original body length. It is not stated if the tightly assembled vertebrae were taken apart when they were cleaned. The length of the skeleton was found to be 3.9% shorter than the total length of the body.

The detailed measurements of both specimens can be found in Table 3.

Discussion

So far as we are able to learn, this study is the first to investigate the elasticity of the spinal column and the skin of a snake.

In our experiments we found that the body of a snake is elastic to a varying degree. We were able to demonstrate that significant stretching of the body is possible when stretching force is applied. This raises a question about a physiological zero-state of the length of any snake. In reptiles, and snakes in particular, it is not known if rigor mortis induces any shrinkage (Cooper, 2012). In mammals, the muscles are stiffened but can only cause slight shrinkage if the muscles are not fixed to inflexible structures (Martin et al., 2001). For our study we draw the assumption that the length of a dead snake post-rigor mortis closely equals the length of a freshly euthanized, an anesthetized, or a relaxed living snake. We have referred to this length as the original or “zero-state” body length.

Body elasticity

Based on this assumption, we found a considerable capacity of the body of our reticulated python to stretch in length up to 10.4% over the original length when considerable force was applied. Of course, what was demonstrated is not possible for a healthy living snake, as it would likely result in overstretching and damaging ligaments and muscles along the spine. However, we realize the potential to use this stretching method to exaggerate the size of a snake. Even the force of two men was enough to enlarge the length by about 3.6%. When a dead, heavy, giant

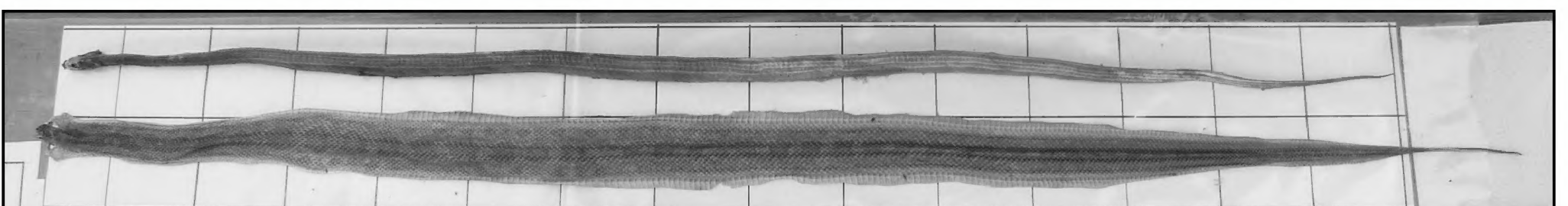


Figure 5. This is the freshly skinned body of the *Pantherophis* specimen positioned above the freshly removed skin before any stretching of the skin was attempted. (Background grid is made up of .10-m squares.)



Figure 6. In the display is the complete skeleton of the gigantic specimen of reticulated python at the Natural History Museum of Denmark in Copenhagen. Collection manager Mogens Andersen is holding a meter-stick in front of the skeleton to show the proportions of the skeleton.

snake is hung by the neck from a roof or tree for hours under warm conditions in the tropics, the same stretching of the body as we observed in our experiment, or even more, might occur. To our knowledge, this phenomenon of the elongation of the snake body has not been described in any quantitative manner in the literature so far.



Figure 7. This display positions the actual complete skeleton of a giant reticulated python specimen over a cast made from the body of the python. Both cast and skeleton are fixed in similar poses. This impressive display is at the Museum of Natural History Basel, in Switzerland.

Benedict (1932) observed while carefully removing the skin of a freshly euthanized *Python molurus*: “There was no question with regard to the length of the snake, although a certain degree of stretching could have been introduced if one had tried to stretch the animal.” Rivas et al. (2008) state: “due to the thin constitution of the snake, the large number of intervertebral joints, and slim muscular mass of most snakes, it is easier to

Table 3. Detailed measurements of three large specimens of *Malayopython reticulatus*.

	Location of specimen		
	Natural History Museum of Denmark [Copenhagen, Denmark]	Museum of Natural History Basel [Basel, Switzerland]	Our own specimen
Specimen description			
Catalogue number	ZMUC R5418	-	-
Collection date	1917	1966	2013
Gender	male	female	female
Original body			
Head length	—	17.2 cm [†]	14.1 cm
Total length	710 cm [23.3 feet]	638 cm [21.0 feet]	587 cm [19.3 feet]
Tail length	—	59.0 cm ^{††}	71.0 cm
Skeleton			
Skull length	16.5 cm	16.5 cm	13.3 cm
Total length	686 cm*	613.3 cm ^{†††}	560.9 cm
Tail length	64.0 cm	61.3 cm	70.0 cm
Precaudal vertebrae	324	325	320
Caudal vertebrae	67**	68	93 (89+4 [§])
Scale counts			
Ventrals	—	317	320
Subcaudals	—	63	90
Degree of shortening from original total length to skeleton length	3.4%***	3.9%	4.4%

* Dried, vertebrae never taken apart.
 ** It's possible that the last one or two caudal vertebrae are missing.
 *** This might be an overestimation depending on potentially missing caudal vertebrae.
 † Measured from cast.
 †† Blunt, snake lost tip during lifetime.
 ††† Tightly reassembled, not clear if ever taken apart.
 § Tip of tail; the tail ends with eight very narrow fragments, which we believe represent four original bones.

stretch a snake than it is to stretch any other vertebrate.” However, no example or comparison is given to support this statement.

Blouin-Demers (2003) found 20 anesthetized *Pantherophis obsoletus* to be 3.7% longer when measured while they are held behind the head and behind the cloaca and stretched out in the air horizontally, than when they are measured by laying them on a table along a metal ruler. This closely agrees with our observation of a 3.6% increase in the length of the python body with moderate stretching force.

From our observations of living snakes, we believe that the maximum physiological elongation of a conscious living snake is far less than what is artificially possible by stretching under anesthesia or after death. We note that it is not known if the spinal muscle apparatus of a snake is able to actually and measurably elongate the spine. Moreover, it is not known if a passive elongation by muscle relaxation, by gravitation or an elongation between two fixing grips is supported by a conscious snake. Our impressions based on experiences with a variety of snake species suggests the opposite—snakes do not willingly allow themselves to be stretched.

Reed (2001) states, based on observations of herpetologist Richard Shine: “Even when stretched for measuring, live snakes retain some muscle tonus, and thus will be ‘shorter’ than the same snakes after euthanasia or anesthesia.” Based on our observations, Reed here is describing a living snake’s unwillingness to allow itself to be stretched beyond its zero-state length. We were able to do this with our dead specimen. Increased length relative to increased stretching force—as Reed mentions—is possible with a euthanized or anesthetized specimen. This requires the expansion of the intervertebral spaces and a stretching of the ligaments and muscle bundles that maintain the intervertebral spaces; this may be painful for a living snake, and it certainly is not an action that an animal with a spine comprising hundreds of vertebrae will voluntarily allow. It’s possible that any forced elongation of a living snake may cause irreversible tissue damage (Fitch, 1987; Setser, 2007).

In our experiments we noticed that after artificially stretching the dead body to different degrees, it repeatedly shrunk back to a length increase of about 1.0%. After skinning, the length was increased to 2.9% more than the original length. If it is possible for a living snake to increase the length of its spine, the potential boundary of the maximal physiological flexibility of the spinal column may allow only a 1% increase in length or less, and certainly no more than a 2.9% increase.

We were not able to directly study if compression of the vertebral column occurs, and we are not aware of any mention of this in the literature. We note that based on the 3.4–4.4% detected difference between the original body lengths and the skeletons of our three large reticulated pythons, there might be sufficient play in the intervertebral spaces to allow some compression of the spinal column. However, the intervertebral spaces are not empty spaces; they are created by the intervertebral cartilage that cushions and lubricates motion between vertebrae. It is not known if this cartilage can be compressed, nor if so, to what degree it might be compressed. Neither is it

known if the vertebrae are equally spaced along the entire length of the spinal column, or if the vertebrae in different sections of the spine are spaced differently than vertebrae in other sections.

We suggest that any ability of a living snake to contract and somewhat shorten its body length is not due to a compression of the spinal column but may be accomplished by creating small zigzag lateral flexures along lengths of the spine, as suggested by Fitch (1987) and described for uropeltid snakes (Gans et al., 1978). This may give the impression of compression of the intervertebral spaces, and certainly does account for reports that snakes can measurably shorten their lengths (Blouin-Demers et al., 2003; Cundall et al., 2016; Lock, 2021).

Based on our experiments we cannot answer if a significant axial elongation and contraction in a conscious living snake exists.

Length difference between body and skeleton

Due to subtle bone shrinkage and the loss of the articular cartilages, a snake skeleton is shorter than the original body (Hoffstetter and Gasc, 1969). The skeleton of the giant specimen of reticulated python at the Natural History Museum of Denmark measures 3.4% shorter than its original length, despite that this skeleton was dried, never disassembled, and retains the intervertebral cartilages. A large, cleaned, dried, and very tightly rearticulated skeleton with the intervertebral cartilage removed is 4.4% smaller than the original body. Hoffstetter and Gasc (1969) use as an example of the intervertebral gaps of reptiles the vertebral column of a crocodile, where this gap represents 11.5% of the actual central length. Klauber (1943) showed that, for a series of snakes of three species, length decreased 2.1–3.2% after preservation in alcohol. This approximates the differences in lengths measured between the original lengths of our reticulated python specimens and the lengths of the three assembled skeletons. After preservation in alcohol, Reed (2001) found variable length decreases ranging up to 7% in 106 examined snakes with lengths of 241–1877 mm. This range of variation may be due to anatomical differences between snake species or to different measuring techniques.

Stretching of the skin

Even the careful and deliberate removal of the skins from the bodies of both our python and ratsnake caused the skins to increase a minimum of 15% in length from the zero-state body lengths. A similar amount of stretching was reported for the skin of the reticulated python named Colossus, as detailed in Barker et al. (2012). Colossus was a famously large python residing at the zoo in Pittsburgh, 1949–1963. At death the zero-state length of Colossus was measured to be 6.35 m; Colossus was carefully skinned at the Carnegie Museum by Neil Richmond, then curator of herpetology, and the skin measured 7.29 m in length, an increase in length of 14.8%.

Reports of skin stretching in the literature include: R. R. Mole measured a 3.11-m *Boa constrictor* just after it had been killed, and reported that after skinning the hide measured 3.71 m, an increase of 19.3% (Mole, 1895); an African python, *Python sebae*, in the flesh measured 2180 mm and its dried skin measured 2650 mm in length, an increase of 21% (Loveridge, 1931); a dead *Python natalensis* measured 3.0 m and the skin

measured 3.65 m, an increase of 22% (O'Shea, 2007). Murphy and Crutchfield (2019) wrote, "It is virtually impossible to remove a snakeskin without stretching it about 20% of its length." They go on to write, "In fact, the skins may stretch much more than the 20% quite by accident, but on occasion, it is on purpose."

We demonstrated that a reticulated python skin can be stretched at least 25.7% in length with most of the scales on the skin still in contact and without any obvious clues to the extent that the skin had stretched. A snakeskin measuring 10 m in length could originate from an 8-m-long specimen without obvious evidence of stretching. A 10-m-long skin, maximally stretched as in our experiment (36.3%), could have been removed from a specimen of 7.34 m.

It is possible that the skin of a freshly killed specimen is even more elastic than our examined specimen that was previously frozen for five years and suffering from freezer burn on a few areas of skin. On our specimen we observed that the paraventral area of the skin along the neck was most sensitive to stretching and seemed more fragile than other areas of the skin. We may have contributed to this with the repeated refreezing that was necessary to complete our investigation.

Moreover, we imagine that an experienced leatherworker with the right tools and assistance is able to prepare and stretch such a skin to an even longer size. Murphy and Henderson (1997) recount a story from Dr. Herbert Spencer Dickey (1932). Dickey wrote that he had a friend in Brazil who prepared and sold snakeskins. Dickey said this person never sold a snakeskin less than 20 feet (6.10 m) in length, but it was doubtful that any of the snakes that provided those skins exceeded 12 feet (3.66 m). Dickey went on to detail that in order to maximally stretch a skin, it was anointed with manatee fat, left in the sun for a day, and then on the following morning one end of the skin was anchored and two men pulled on the other end to stretch it. With this method the length of any snakeskin could be increased by at least 50%.

We saw almost no gaps between the scales until the snakeskin was stretched by at least 36.3%. In contrast, Bellosa et al. (2007) state that if no gaps between the scales are visible, no skin stretching exists. Our data and observations suggest that even if the gaps between the scales are known, accurately calculating the original length of the snake is not possible.

However, we considered that it might be possible to accurately predict the total length of a snake based on the dimensions of some particular scales on the body. As snakes age and grow, the number of scales on their bodies does not normally change significantly. Injuries to the skin may heal with different numbers of scales, but generally a snake has the same number of scales on its body throughout its life. Of course, the scales do

grow, increasing in length and width. Snakes grow at different rates, according to a variety of environmental and genetic factors. It seems then that scales likely grow at a rate similar to rate of growth of the size of the snake. We were unable to further investigate this possibility.

The elasticity of snakeskin can work in two ways. While a fresh skin is always longer than the snake, a skin that is not cleaned properly and pinned down during the drying process can shrink to a shorter length than the actual snake body. One example of this is the skin from the famous giant reticulated python, Samantha, who resided at the Bronx Zoo, 1993–2002. Samantha's necropsy report stated that she measured 22'5" (6.83 m) at death. She was missing 12 inches (0.31 m) of tail that was amputated earlier in her life. Including the missing length of tail, her zero-state length at death would have been 7.14 m. In January 2012, Dr. David Kizirian, curator of herpetology at the American Museum of Natural History, provided us with the following information: "The skin (AMNH-R 154610) is contorted making an accurate measurement impossible, but in its current state it measured 17' [5.18 m]. The head and tail are intact."

Conclusions

With this study we show the size difference between the length of a skeleton and the zero-state length of the snake. We also illustrate the stretching capacity of the skin from a large python. Additionally, we report on the artificial stretching capacity of a dead snake body. However, the potential physiological elasticity of a living snake remains a question open to further research.

This is the first paper in our investigation of the record length and maximum size of the reticulated python. Lengths reported and purported for potential record-size reticulated pythons have been based on skins, skeletons, and measurements of unrestrained, restrained, anesthetized or dead specimens. The findings here will aid in evaluating such potential records.

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Book Review: *Exotic Amphibians and Reptiles of the United States*

by Walter E. Meshaka Jr., Suzanne L. Collins, R. Bruce Bury and Malcolm L. McCallum

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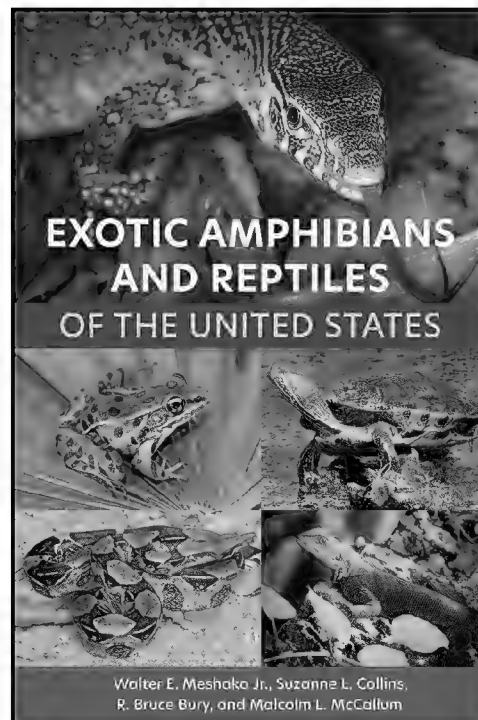
In my mind's eye, the word "exotic" conjures up pleasant images of far-away places that are home to mysterious, never-before-seen fauna and flora. The term "exotic," however, has an undesirable flipside. The use of "exotic" in the title of this book refers to the negative definition and addresses non-native amphibian and reptile species that have been introduced by humans into the United States from elsewhere in the world as well as native amphibians and reptiles that have been moved by humans beyond their native distribution within this country.

The book was co-authored by four well-known herpetologists. The senior author, Walter E. Meshaka Jr., is senior curator of the Section of Zoology and Botany at the State Museum of Pennsylvania and has published extensively on the establishment of populations of exotic amphibians and reptiles in the United States, particularly in Florida. Second author Suzanne L. Collins is a wildlife photographer and—along with her deceased husband Joseph T. Collins—published several herpetofaunal guidebooks. The third author, R. Bruce Bury, is a retired research zoologist with the U.S. Geological Survey, Corvallis, Oregon and has published extensively on herpetofauna of the Pacific Northwest. And finally, Malcolm L. McCallum, a research scientist in the Department of Agriculture and Natural Resources at Langston University in Oklahoma, has published an eclectic assortment of articles, with an emphasis on herpetofauna.

The 6 1/8- × 9 1/4-inch, glossy-paged book fits nicely in the hand, and has an attractive cover graced with color images of two lizards, one frog, one turtle, and one snake. It comes in a hardcover printed version as well as various e-book versions. My hardcover review copy is sturdy and well bound.

Following acknowledgments and introduction sections, the book is divided into six major divisions based on taxonomy: Part 1, Salamanders; Part 2, Frogs and Toads; Part 3, Turtles; Part 4, Lizards; Part 5 Snakes; and Part 6, Crocodilians. Based on the number of species per division, it quickly becomes obvious which taxonomic groups are least likely to establish populations outside their native range (Crocodilians [1 species], Salamanders [3 species], and Snakes [7 species]), and which are most likely (Lizards [62 species], Frogs and Toads [18 species], and turtles [12 species]). Geographic origin of exotic species varies considerably among these groups. For example, whereas 96.8% of exotic lizards originate outside the United States, 83.3% of exotic turtles originate within the United States.

Species accounts for all 103 taxa comprise the bulk of the book. The book also includes eight short essays scattered



throughout, three of which were written or co-written by the book authors and five of which were written by colleagues. A list of references, a list of journals consulted for geographic records and natural history information (including *Bulletin of the Chicago Herpetological Society*), information about the authors and contributors, and an index to taxa (both common and scientific names) follow the species accounts.

I know many of us initially ignore the introductory text, and opt instead to first peruse species accounts when a book such as this lands in our hands, but I highly recommend resisting that temptation and reading the introduction first. Here, on page 1, we find the authors' definition of an exotic species ("A non-native species whose presence is the result of human-mediated dispersal outside its indigenous geographic range"), which is crucial in understanding why they included the species they did. In addition, we learn that despite the book's early 2022 printing, the literature search ended two years earlier at the end of 2019. We also learn that isolated records are not mapped in a particular state unless that species has an established reproducing population in that state. We further learn that the authors strongly prefer collection of specimens of exotic species (which they describe as "proof") for deposition into a museum over photographic records. For example, on page 8, they express their opinion that "photographic records are generally of limited value" and "As a matter of practice, we advocate the collection and deposition of specimens." The authors' seeming distrust of photo vouchers is rather surprising given the museum practice of cataloging good quality images which can serve as vouchers for county records published in *Herpetological Review*, and their acceptance in online invasive species databases such as the Early Detection and Distribution Mapping System (eddmmaps.org). Not everyone is willing to kill an animal for a voucher specimen, even if it is outside its native range and potentially problematic. Furthermore, many people do not have a museum nearby nor have a relationship with a museum curator. I think it best-practice to encourage citizen science by accepting as valid, good-quality photo vouchers that include accurate geocoordinates. If deemed necessary, photo vouchers can later be verified by the collection of a specimen by a scientist. By encouraging citizenry to contribute photo vouchers, we greatly increase our chances of discovering undetected populations of exotic species.

Species accounts include: 1) a description of each species including metrics such as size, color, and pattern; 2) one or two color images; 3) a brief history of introduction and description of the introduced geographic range (including a county-level

geographic distribution map current through 2019); and 4) details of the species' ecology such as habitat, reproduction, diet, predators, and potential and documented impacts. Especially intriguing is frequent mention of interaction among exotics—especially lizards—such as competition, predation, and displacement. Apart from a few of the images acquired from the internet, the photographs are excellent.

Stated goals of the book include (page 1) “provide an up to date documentation of the exotic herpetofauna as a tool for management professionals, researchers, citizen scientists, and naturalists” and (page 2) provide “a synthesis and up-to-date, practical source that documents the presence and ecology of the exotic herpetofauna of the United States.” The book is meant to be a comprehensive compendium of exotic amphibians and reptiles in the United States. The authors express confidence in the completeness of their work by stating on page 12 that “a researcher wishing to publish new records can cite this book and any additional records published after 2019.” Unfortunately, this statement may not be entirely accurate.

As I thumbed through the species accounts, I was surprised to see that Northern Dusky Salamanders (*Desmognathus fuscus*) are not included as an exotic species in Illinois. Illinois' native Spotted Dusky Salamanders (*Desmognathus conanti*) are restricted to a particular geologic formation in Pulaski County near the southern tip of the state (Brandon and Huheey, 1979). However, in 1986, a dusky salamander population was discovered in Johnson County beyond the range of this geologic formation. The derivation of this population long puzzled Illinois herpetologists. In an exemplary example of scientific sleuthing, the identity of the Johnson County dusky salamanders was resolved by Shepard et al. (2016), who identified them as Northern Dusky Salamanders. They also determined that the likely source of this population was the Cumberland Plateau of Tennessee. Was this species omitted from the book because the Illinois exotic population does not meet the authors' criteria for inclusion or was it an oversight?

I also noticed that the map and description of the range of Cuban Treefrogs (*Osteopilus septentrionalis*) does not include Louisiana. Louisiana specimens of Cuban Treefrogs have been collected and deposited into museum collections since 2014 (Chatfield and Vance, 2014), and a breeding population inhabiting New Orleans was reported in 2018 (Glorioso et al., 2018). From my perspective, it seems the combination of these observations would be sufficient evidence to map the occurrence of Cuban Treefrogs in Louisiana. The omissions of Northern Dusky Salamanders from Illinois and Cuban Treefrogs from Louisiana are concerning, and make me question the utility of the book as a one-stop-shop for information on exotic amphibians and reptiles through 2019. Although an excellent contribution to our understanding of the distribution of exotic herpetofauna in the United States, perhaps the criteria for which species to include or where to map their occurrence are too restrictive. In any case, I suggest researchers look beyond this book before submitting a range extension manuscript.

One of the more potentially useful aspects of the book is the section within each species account entitled, “Introduction history and geographic range.” The depth of information in this

section varies considerably among species. For example, this section ranges from 50 lines of text for Mediterranean Geckos (*Hemidactylus turcicus*) to only two lines for California Red-legged Frogs (*Rana draytonii*). Whereas many of the longer accounts provide dates of a taxon's introduction and/or establishment in an area, as well as source(s) of the introduction, many shorter accounts simply describe the taxon's geographic range. Similar uneven coverage can be found in the Ecology section of each species account. Presumably, this unequal treatment reflects the state of our collective knowledge of each species.

On page 12 of the Introduction, the authors suggest that a “researcher interested in conducting a full review of a given species in this book can use the sources in the references as a starting point.” I attempted to do this with Wood Frogs (*Rana* [*Lithobates*] *sylvatica*) and Two-lined Salamanders (*Eurycea cirrigera*). Although both species are native to Illinois, they are reported as exotics in the state because populations of both species were purposely established in portions of the state that are well outside their native ranges. In the species accounts, the authors state that individuals of these species were transported into Illinois from Indiana in the 1970s and 1980s in the case of Two-lined Salamanders and the 1980s in the case of Wood Frogs. However, the list of references does not include the two papers (Thurow, 1994, 1997) that detail these introductions. It is apparent that the list of references is incomplete and may not be as useful as a literature review starting point as suggested by the authors.

Despite the shortcomings described above, I like the book and believe that it will satisfactorily serve those interested in learning more about exotic herpetofauna in the United States. There is much information to be gleaned from the species accounts and I find the inclusion of native species transported outside their native range to be quite enlightening. Although I was thoroughly aware of the introduction of Bullfrogs (*Rana* [*Lithobates*] *catesbeiana*) into western states and Red-eared Sliders (*Trachemys scripta elegans*) into Florida (as well as the introduction of both species across planet Earth), I was unaware that so many other native species have established populations beyond their indigenous range.

The book is very well written and edited, and—except for the following—errors are nearly nonexistent: *Eurycea cirrigera* is consistently misspelled as *Eurycea cirregera* several times, “most” is used in place of “moist” on page 221, and metric units of measurement are used on pages 168 and 174 rather than English units which are used throughout the rest of the book. This tome is an attractive compilation of exotic amphibians and reptiles that are currently prowling outside their native ranges and, in some cases, wreaking havoc on the foreign ecosystems they now inhabit. I think one of the book's greatest strengths is that it brings to the forefront the serious problem of exotic species in general, not just the amphibians and reptiles that are featured. These issues are mentioned in the Introduction and in the essays. We humans must do better. Early detection and prompt control of novel exotic species are critical in reducing the likelihood of their establishment. You can do your part by learning to recognize non-native invasive species, whether they be plant or

animal, and supporting efforts to eradicate or contain them. Repeatedly, the authors describe the derivation of many exotic species as “the pet trade.” Should you tire of your pet amphibian or reptile, *please* do not release it outdoors. Find it a new home!

Acknowledgment

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About This Month's Cover

Caitlin Monesmith's image of a panther chameleon shared first place in the contest for best photograph conducted at the January 26 virtual meeting of the Chicago Herpetological Society. Caitlin had this to say about her entry:

I took this photo at the Louisville Zoo. Their naturalistic exhibits are a great place to photograph animals. Zoos are an interesting place to photograph animals because while some aspects of wildlife photography are much easier at zoos (you know the animals are there, for a start!), reflections, exhibit glass, and barriers like fences can make getting a clean shot a challenge. Ever since the pandemic started, I've been visiting zoos much more frequently and taking pictures there, since there are several excellent zoos with great reptile exhibits within driving range of my apartment in Chicago or my parents' house in southern Indiana.

At the Louisville Zoo, the brightly-colored panther chameleon exhibit is one of the first things you see when you enter their reptile building, and it sets the tone for the rest of the visit. I've always been fascinated by reptiles (I kept my first lizard, a green anole, when I was six. That was 25 years ago!), and especially with the way we keep them in captivity. A good captive environment provides the animal with all that it needs to not just survive, but to thrive. Part of making sure that any reptile is happy in human care is providing enrichment — mental and physical stimulation. This can come in a lot of different forms, and for chameleons, it's always seemed to me like they like having something to watch — like zoo guests! Chameleons in particular are highly visual creatures and it always seems like they're watching you just as closely as you are watching them.

The Life and Times of a Gila Monster named Laura — Part 1

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No biologist has yet discovered a Gila monster nest in the wild so the animal's natural egg-laying locations and procedures remain a mystery. (Brown and Carmony, 1991: page 44)

Prologue

When I first read the words above in a hot-off-the-press copy of the book *Gila Monster: Facts and Folklore of America's Aztec Lizard* (Brown and Carmony, 1991), I somehow *knew* that I was going to be the one to discover that first wild Gila Monster nest. I didn't just *think* I would be the one, I *knew it!* My method was going to be to mob the Sonoran Desert surrounding Tucson, Arizona with everything I had. I was going to find the places that had the most Gila Monsters, and zero in on them. By 1991, I was spending more time in the field than the pros were, and that effort only escalated throughout the last decade of the 20th century. I knew that finding that nest wasn't going to be easy. It was something akin to the quest for the Holy Grail. But what I was seeking was *far* more important to me than some trivial religious trinket. One fine day, *somebody* was going to be the first to witness a half-dozen or so little black snouts poking out of holes beneath a patch of desert shrubbery, and by golly, I *knew* that somebody was going to be me!

Even though an entire decade passed without me finding the nest, I *still* never lost faith. When in March of 2001, I joined forces with Dr. Gordon Schuett to do a radio-telemetry study that included Gila Monsters, I *knew* that technology might be the key. And when on 7 April 2001, Gordon Schuett gave me the phone call to tell me the news that the Gila Monster we captured six days previous was a female, I said "*Hot-DIGGITY-damn!*" For I didn't just *think* we had this here first Gila nest in the bag, I *knew it*. Destiny was around the corner.

Shorthand used for Gila Monsters in this column

As much as I *hate* to destroy the terrific momentum of my prologue, this author is tired of constantly using this "Gila Monster" stuff already. From this point forward, when speaking generally about them, I will often use the acronym "HESU." The word is merely a combination of the first two letters of the genus combined with the first two letters of the species, all four letters *always* capitalized for reasons unclear to this author. When speaking specifically about *Heloderma suspectum* #2 of the Suizo Mountain Project, I will either use the abbreviated form Hs2 (without the bothersome italics associated with a dead language), or more often, her Gord-given name of "Laura." One last annoying detail stands in the way of my proceeding with the story of Laura, and that is to suggest that her capture occurred on 1 April 2001. The story of her capture can be found in last month's issue of the CHS *Bulletin* (Repp, 2022).

Laura's release day, 8 April 2001

Several euphemisms come to mind when I speak of the release of Hs2 (Laura). "Ill-conceived and poorly executed"

comes to mind, as does "lackluster." As far as the raw data of the event goes, we could even get biblical: "And the datasheet was without form, and void, and darkness was on the face of it." But overall, the best description of my own handiwork can be found right on the datasheet itself. "This datasheet is piss poor. Badly done." Yep, Laura's formal entry into the hallowed Suizo Mountain Project was indeed amateur hour at its finest. First off, as soon as she went northward with Schuett, he no doubt plied her with HESU treats and bon bons. Schuett's favored concoction was a mixture of eggs and pinkie mice, which a hungry HESU like Laura will *always* consume, no matter the circumstances of such trivialities as a recent capture or subsequent post-capture stress. I'm sure that Laura wolfed down every morsel of what was offered, for I saw the evidence of it when Gordon first showed her to me on her release day. It would have been *great* if the good Dr. Schuett had documented a mass on Laura's gluttonous banquet, but that didn't happen. It would have been even *better* if the author had obtained a release mass, but *that* didn't happen either. On top of feeding her until she was fit to bust, Schuett had performed the surgery to implant the 11-gram transmitter on 7 April—the day before. And let's not minimize the flandickery of Laura's actual release. Let's just say it was 14°C (57.2°F) when we placed her on the flat rock that she was first observed streaking across one week previous. Her movements on 1 April—when it was hotter than the hinges on the gates of Hell—were spry and sprightly. On 8 April, she just sort of lay there all bloated like an orange and black sock full of pus, growing goosebumps so large that they hid her osteoderms. *Everything* about her demeanor on this day indicated: "Did anybody catch the number on that bus I was just thrown under?" For the sake of posterity, we share an image of Laura at the initial moment of release (Figure 1). We watched and waited for

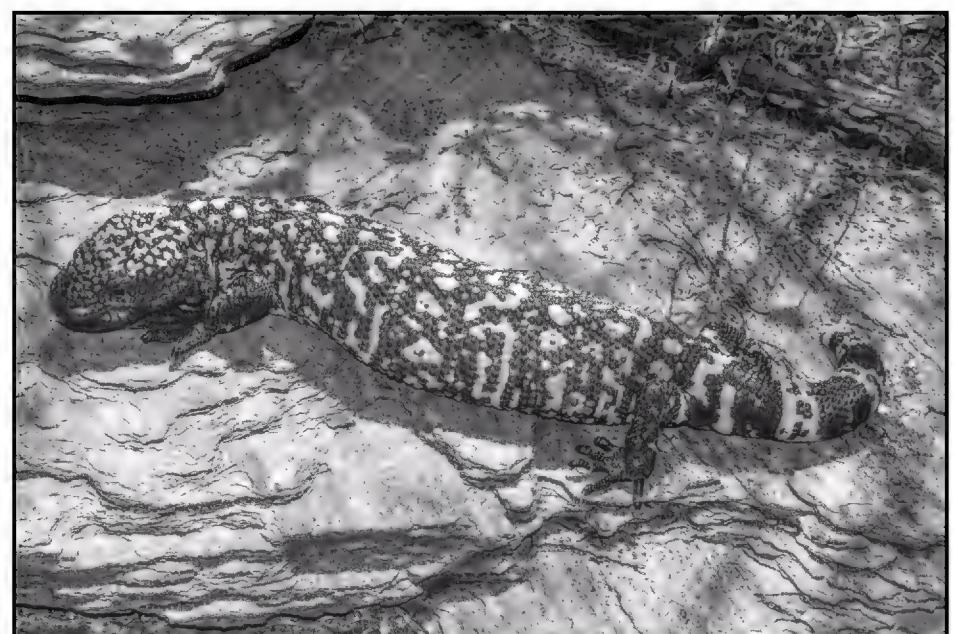


Figure 1. *Heloderma suspectum* #2, AKA "Hs2" or "Laura," gets off to a slow start upon her release. See text for details on this and all other images. All photos are from south-central Pinal County, Arizona, and all were taken by the author.



Figure 2. The southwest side of Iron Mine Hill, Laura's home from September to April of every year that she was in the Suizo Mountain Study. See text for details of "ping-pong" movements that allow for some overlap of Laura's monthly activities and habitat usage.

an hour until she *finally*—so slowly that we needed to paint a line in front of her to see if she was actually moving—began to head for the hole that she so briskly tried to enter the week before. It was *not* an auspicious beginning for Laura *or* the Suizo Mountain Project's data collection. However, when I looked back on the datasheet for this day on 2 May 2001, I rallied around the cause, and inscribed the following words: "I will strive for excellence with all future recordings. It is our biggest edge." Truer words were never spoken. As we continue with the first two years of Laura's life as our study subject, I will quote the occasional snippet from my raw data.

Laura's World

While the author has spoken often of Iron Mine Hill, Suizo Wash, and the Suizo Mountains, never have I included any images that show all three places in the same column. The Suizo Mountains are 50 miles due north of the center of Tucson. Iron Mine Hill (IMH) is a free-standing outlier of the Suizo Mountains proper. The northern extent of IMH is separated from the southern extent of the Suizo Mountains proper by a 400-meter-wide (on average) sandy drainage named Suizo Wash.

Where the Gila Monster aspect of the Suizo Mountain Project is concerned, I can honestly say that everything we needed to know, we learned from Laura. To be sure, we needed input from the male side of the HESU equation as well, as there is a *huge* difference in the home range requirements with males. But good old Hs1 (Geronimo) filled us in on the details, and he was in the game before, during and after Laura. But be they guys, or be they girls, they *all* behaved similarly where landscape usage on Iron Mine Hill and the Suizo Mountains was concerned.

Iron Mine Hill is roughly 70 meters tall by 300 meters wide by 600 meters long. The base of IMH is at roughly 800 meters in elevation, and 870 meters at the top. The hill itself is gentle in aspect, and in places, covered with massive metamorphic schist formations of granite-like gneiss (Figure 2). Peppered all about on the flanks of IMH is a near-equal distribution of individual boulders and various pockets of plants. Said plants include such giants as saguaros, scaling down in stature to ocotillo, stunted mesquite, palo-verde and acacia, down even more to prickly

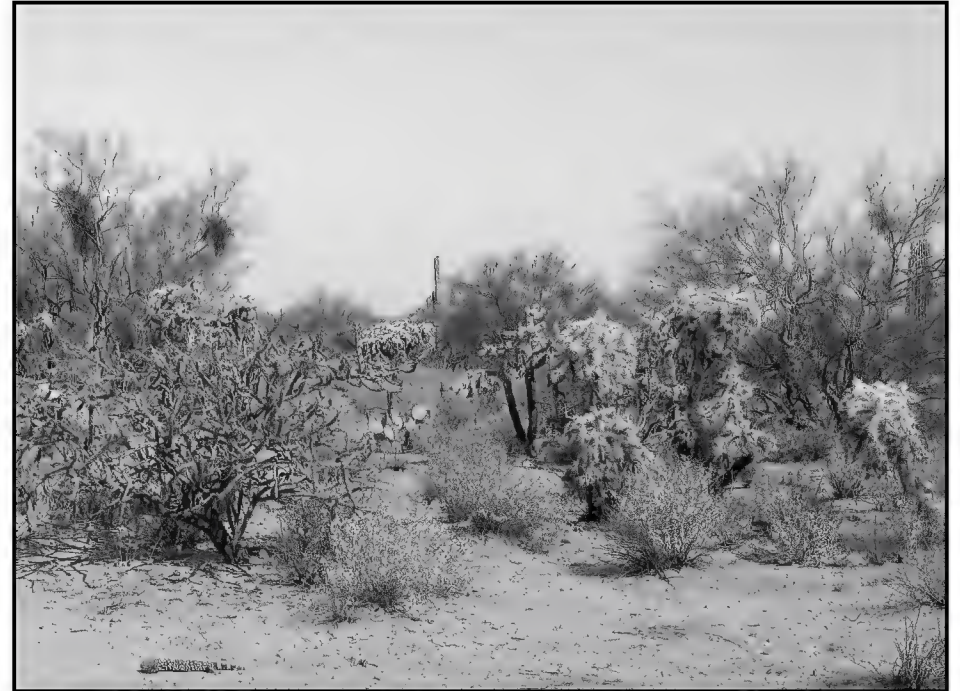


Figure 3. The bajada to the south and west of Iron Mine Hill was Laura's playground in late March through May. The HESU in this image is not Laura, and is also not part of her story (as far as we know).

pear, limber bush, creosote, and desert oregano to various smaller flowering plants such as desert lavender, penstemon, *Trixis*, larkspur, lupine, and a magnificent assortment of others. From September to mid-April of every year we watched her, Laura's world was entirely on IMH. Laura moved about on this hill at will, but basically remained on its upper southern and western slopes until mid-April.

From mid-April to end of May, Laura entered a different biome. The south and southwest side of IMH is ringed by a narrow and fairly level plateau. Said plateau absolutely bristles with *nasty* chain-fruited cholla, some of which stand over two meters tall. Their presence assured that the ground surrounding them was coated with their nasty segments whose needle-sharp spines can getcha from any direction (Figure 3). This is also a land infested with Packrat middens that are in turn surrounded with menacing prickly pear cactus. In order to further fortify their little fortresses, the industrious Packrats also snag loose cholla segments and pile them at the entrances to their lairs in formidable fashion. Also ubiquitous on this plateau are lush stands of creosote bush, many of them also over two meters tall. The soil under the creosote is friable, and forms mounds of sorts that are peppered with the holes of kangaroo rats, pocket mice, and many other forms of life too numerous to mention here. And scattered throughout the works stands the dominant plant of the region, the omnipresent triangle-leaf bursage. The southern edge of this plateau gradually slopes down into a two-meter-wide sandy wash that we eventually named "Laura Wash," due to her prodigious spring and foreshummer use of it.

From late May through August, Laura would enter Suizo Wash. This is an enchanted land of wide, sandy channels shaded by massive ironwood, mesquite and palo-verde trees, some of which exceed eight meters tall. Peppered about at the edges of the channels are impenetrable stands of hackberry, some pushing over four meters tall by 30 meters in diameter. All of the other plants mentioned above can be found on the many high and dry islands that the occasional floodwaters carve into the many channels that crisscross the westerly flow of this major drainage of the entire Suizo system (Figure 4).

By early September, Laura began to commit to Iron Mine



Figure 4. The northeast flank of Iron Mine Hill is in the foreground, with the southern limit of the Suizo Mountains to the rear. Laura was never in the Suizo Mountains that we know of. However, she used Suizo Wash extensively from end of May through August of every year that she was under watch. The “big wash,” as we sometimes called it, is shown in flood stage, the raging waters clearly demonstrate how the channels and wash islands are created.

Hill again. September through March is actually a very lean time for Gila Monsters. If they are not well-fed by September, they are indeed a sorry-looking mess. (Laura never had that problem.) Once back on IMH, she would use her known system of “Gila Holes” (the holiest of *all* herpetological holes) to leisurely work her way upward to her overwintering site. The author has just said a mouthful in that last sentence.

We’ll start with Gila Holes. An adult HESU like Laura has an entire series of Gila Holes that she has learned through the years (Figure 5). While the hole systems that she knew spanned a width of 300 meters north-to-south by 500 meters east-to-west, she always knew where to flee when caught in the open. She was *never* far from a known Gila Hole. And while I have spoken of a general seasonal flow of Laura’s movements, she could easily hop from a hole known to both us and her in the middle of Suizo Wash to the same situation at the top of Iron Mine Hill. She would often make what we called “ping-pong” moves, where she could go from the upper extent of Iron Mine Hill to the bottom and back up again. She would use the same hole both at the top and bottom several times over during the course of a week. I also mentioned overwintering as opposed to hibernating, as Laura was ever-alert and visible in the shelters she used. And Laura literally took the term “overwintering” to almost an exact astronomical science by matching the winter solstice and spring equinox. For both years under discussion, ingress by 22 December, egress by 19 March! But Laura differed from the rattlesnakes with which she shared her turf by often ping-ponging back to her overwintering shelter well into the month of April. By comparison, when Western Diamond-backed Rattlesnakes (*Crotalus atrox*) egressed, they did not return until the late fall.

May 2001: a quick outside look at Gila Holes and ping-pong moves

The ocean is a desert with its life underground and a perfect disguise above

Man did Dewey Bunnell of the band America ever knock one out of the park with the above line from the 1972 hit song “A Horse with No Name.” He could easily have been singing about

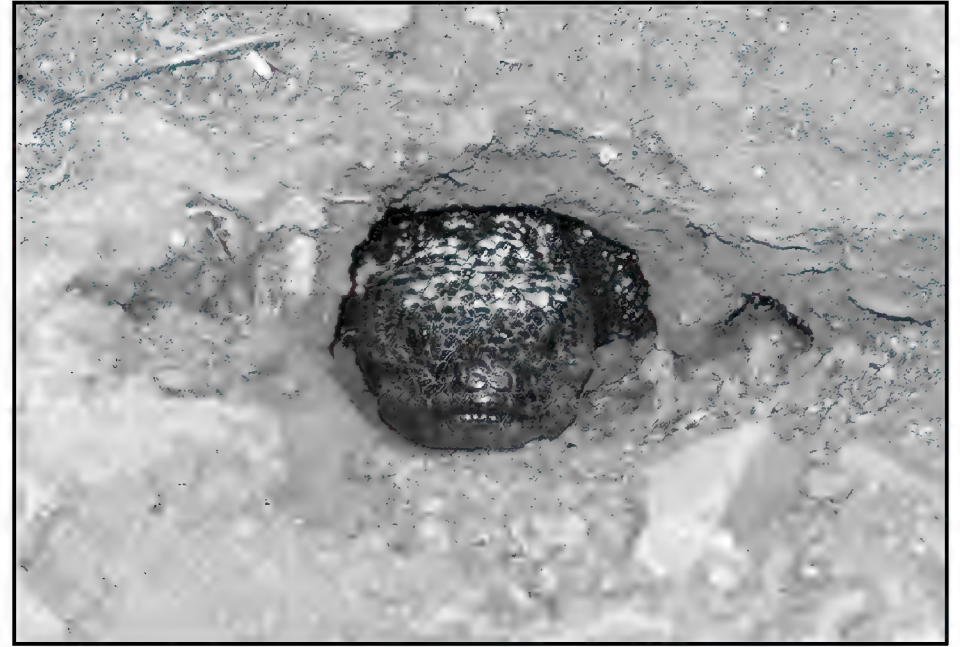


Figure 5. There is much talk of “Gila Holes” during the discussion of Laura’s May 2001 ping-ponging antics. This is a hard-to-get image of Laura actually visible in a Gila Hole. (The words “Gila” and “Hole” are both capitalized to show respect—a Gila Hole is a Hallowed Hole—not to be confused with any other type of hole in the desert.)

Laura, with her life underground and her perfect disguise above. In Part 2 of this column, I will describe the intricate labyrinth of underground tunnels and chambers that can only begin to be understood by applying a shovel to the ground. But during the first full month of radio-tracking Laura, which was May of 2001, I was not even thinking of ever digging into a HESU site. But I was of course documenting everything that I was seeing above ground. And what I was seeing were Gila Holes and ping-pong moves, with but limited comprehension of the circumstances that Laura actually faced with her subterranean existence. I was on the outside, but I was *not* looking in! While a table would probably be ideal for what comes next, I instead use complete paragraphs to describe 18 days of radio-tracking Laura in May of 2001.

5 May 2001, 1000 hours. Site #5. For the sake of demonstrating Laura’s quirky movement patterns, we call Site #5 ground zero. Laura was observed by Schuett and Repp on an open patch of ground for a full three minutes. She was tongue-flicking the soil, moving somewhat erratically in the process. Once she took note of us, she ambled into an old, unoccupied badger hole.

8 May 2001, 2236 hours. Not visible, Site #6. Laura has traveled 322 meters to the southeast, and has used a Gila Hole to enter a Packrat midden under a *miserably* dense stand of chain fruit cholla. Meanwhile, it’s 10:36 P.M., and there’s young Repp radio-tracking alone. What a guy—what a moron!

12 May 2001, 1028 hours. Not visible, Site #7. She has moved 296 meters northwest—ping-ponging close to ground zero again. Repp and Schuett note she is in a Gila Hole under a network of kangaroo-rat holes under a creosote.

13 May 2001, 1743 hours. Not visible, Site #7. No change since yesterday.

17 May 2001, 1856 hours. Not visible, Site #8. Another ping-pong move of 303 meters southeast. Make up your mind, sweetie. Which way are you going? I will exactly quote my data-sheet here: “Hs2 is beneath ironwood tree riddled with 9 Gila Holes within a 3 meter diameter of trunk. One had Gila tracks all around it” (Figure 6).



Figure 6. On 17 May 2001 Laura has used one of the Gila Holes in the foreground to go under an ironwood tree.

19 May 2001, 0740, 1335 and 1801 hours. Not visible, Site #6 (again—see 8 May). She has traveled 116 meters northeast in order to wind up under the exact same stand of chain-fruit cholla (Figure 7). Dr. Phil Fernandez of Grand Canyon State University joined Schuett and Repp for the day. At 1801 hours, when I made my last visit to Site #6 alone, there was no signal to be had. I chased my tail trying to find that signal, until I picked up a very faint signal from near our usual parking spot. Wherever she went between 1355 and 1801 hours was likely 300 meters or more to the west! Nothing to it for a Gila Monster!

23 May 2001, 1804 hours. Site #9. Only Laura knows how far she actually traveled between her “whereabouts unknown” location to her crawling spot on this day. I only know that she was 195 meters northwest of Site #6 four days after her disappearing act. She was observed and photographed following a rodent run beneath bursage and prickly pear cactus (Figure 8). Site #9 was on the bajada very close to our parking spot – the place where I could barely discern her signal on 19 May.

When all was said and done, over the course of 18 days in May of 2001, Laura traveled 1232 meters of straight-line measurements. On day 18, she was a mere 152 meters south of her ground zero starting point (Site #5). We really don’t know how far she actually moved across the ground in order to go nowhere in particular, but we can assume the distance was well over a mile! Her movements made zero sense to me, especially in the



Figure 7. On 8 May, and again on 19 May, Laura has used a Gila Hole to get under this *nasty* chain-fruit cholla mess.

light of what our three telemetered Western Diamond-backed Rattlesnakes (*Crotalus atrox*) (Ca) were doing at the time. Ca1 (Ruth), Ca2 (Dianna) and Ca3 (Patricia) were all moving in fairly straight lines—albeit three different directions—*away* from their home base of *Atrox* Den #1 (AD1). We were getting our first glimpse of the habitat niche partitioning between the species. The *atrox* were making a beeline to get as far away from Iron Mine Hill as possible before establishing their home range, while Laura made monstrous moves only to keep bopping back.

Laura reacts to a rare monsoonal storm

We of course had no way of knowing it, but we began our study at almost the exact time that the worst drought cycle in 1200 years began in the American Southwest. Prior to the year 2000, we might expect an average rainfall of roughly 12 inches per year. In 2001 and 2002—the first two years of our study—the totals were 7.81 and 7.84 inches respectively. Over the course of our 15-year study, we averaged just above 9.6 inches. And it got worse after that!

From the beginning of June 2001 through 24 July, we did not see any rain to speak of. We visited Laura 19 times during this time period, and only saw her surface active once. Despite the fact that we *always* timed our visits at optimal times of HESU activity—early morning, dusk, or dark—she was underground



Figure 8. On 23 May 2001 Laura is seen for the first time in nearly 18 days. She is first viewed and photographed following a rodent run that travels beneath prickly pear and bursage.



Figure 9. On 25 July 2001 came the one and only flood event of Suizo Wash that happened during the 3.5 years that Laura was in the study. On 22 July—three days before the flood—radio-tracking had located her not visible in the deepest recesses of one of the wash channels.

95% of the time during the dry foresummer months of 2001. She was frequently in the deepest recesses of Suizo Wash during this time period. But on 25 July, the heavens ripped open, and the very late “first-nighter” of the monsoon season was on. And so was I! As soon as it was safe to do so, I headed for the Suizos. When I stepped out of my vehicle, my ears were filled with the welcome roar of raging floodwaters coming from Suizo Wash. It was the first time *ever* I heard that sound, despite the fact that I had been visiting Iron Mine Hill since 1992. The storm on this day was my first experience with a gully-washer in Suizo Wash (Figure 9). As I threaded up my antenna and receiver, I began wondering if I was going to have to wade my way to Laura. Once everything was fired up, I swung the antenna toward Laura’s last known location, which was over 200 meters north of our parking spot—the direction of the “big wash” as we often called it. I dialed the signal down to a whisper, and turned toward Iron Mine Hill. The signal became powerfully loud in that direction. I knew then that Laura had the good sense not to let a flash flood sweep her away, or worse yet, drown her in some soggy Gila Hole version of Davy Jones’ locker. Nope! She was safely on the hill, and up I went.

There are many disadvantages to radio-tracking at night. The author could fill an entire column with the bumbling, fumbling flandickery of antenna discard; thermometer placement (where the *hell* did I put it?); eyeglasses off (where the *hell* did I put them?); eyeglasses on; flashlight off, headlamp on; datasheet, GPS unit, and compass removed from my backpack and scattered about the landscape; *where the hell is my pen?*; and maybe—just maybe—camera being ready for that potential money shot. Where tracking a wary and skittish HESU like Laura was concerned, the beam of my cinder-block sized flashlight (the powerful, compact

LED flashlights of today had not yet been invented) rendered a stealthy approach impossible. I might as well have been blowing a bugle, but would have needed a third hand to do so.

Despite all this flandickorous night-fighting bullshit working against me, I *almost* got a photo of something very cool (Figure 10). As the scanned 35mm slide image clearly demonstrates, the author found Laura on top of a boulder. When first observed at 2014 hours, her head was thrust into a small pool of rainwater that had collected in the recesses of the boulder top. By the time I could clear the way for the “money shot” (like there ever was such a thing where a herp is concerned), she was turning away from the puddle. My flash went off just before she scrambled off the top and landed with an audible plop on the ground 30 cm (12 inches) below. I *almost* got a picture of her drinking from this puddle. There are *many* questions that every aspect of this observation raises. A few are: How did she know to get out of the wash? How did she climb to the top of that steep boulder? And how did she know that a drink of water awaited her on the top? Welcome to the mysterious world of HESU, where speculation is not allowed, and deep-running questions become only endless holes of difficult-to-prove, hypothesis-driven science!

February 2002—Laura’s first known boyfriend appears

Lyrics from the 1971 song “13 Questions,” written by Kulberg and Roberts, and performed by their band “Seatrain:”

*Deep in the darkest hour of a very heavy week,
Three Earthmen did confront me, and I could hardly speak.
They met me in a hurry, they left me tired and sore,
And when I’m fit for wishing, I hope they’ll come no more . . .*

*They showed me 19 terrors and each one struck my soul.
They threw me 13 questions, each one an endless hole.*

For whatever reason, even though Hs1 (Geronimo) overwintered very close to Laura’s overwintering site of 2001 to 2002, the pair did not ever meet that we know of. Upon egress in 2002, Geronimo headed east, and Laura headed west. Laura entered her overwintering site on 22 December of 2001. (Ingress! The day after the winter solstice!) While we’re at it, she



Figure 10. Laura on 25 July 2001 at 2014 hours, just after the biggest rain event of 2001. She was first viewed drinking from a small puddle on top of the boulder that she is poised on. She spooked and swung away from the pool before the author could get the photo. Was it luck or brains that motivated Laura to clear out of the big wash before this flooding event happened?



Figure 11. (Left) There are two Gilas in this crack! The future Hs5 as first viewed in Laura's overwintering crevice (her site #34) on 24 February 2002. He was captured on 2 March (see Figure 12) and sent home with Schuett for a transmitter implant. (Right) 7 March 2002. Upon release, Laura's boyfriend briskly enters the crevice of his lady, who is still there for him.

egressed for the first time on 19 March 2002. (Egress! First day of spring? Pretty darn close!) Laura's first overwintering site was the quintessentially perfect combination of insulation from the cold coupled with a 100% shot of visibility of *everything* inside of it. The shelter itself was a smooth-bottomed crevice, the equally smooth top being exactly the height of the back of an adult HESU like Laura. At most, the crevice was 60 cm (23.6 inches) deep, and it faced exactly 180 degrees due south. The southerly aspect of the crevice combined with its location near the top of Iron Mine Hill guaranteed sun all day, and only rarely was a mirror or flashlight necessary to see what was going on inside of Laura's world. That is why on 24 February of 2002, I was able to see that there were now *two* Gila Monsters inside that crack (Figure 11, left). At the time, it was the earliest-known visual of a pairing of wild HESU ever recorded (Dan Beck, pers. comm.) The pair was stuffed inside that crack in a classic yin-and-yang 69 position, the male toward the outside, and the female to the inside. If HESU ever perform mutual cloacal licking, everything was in the right place, less than a tongue-flick away. Based on what horned lizards do, that is not as far-fetched as it may seem (see Sherbrooke, 2003: p. 133, pl. 101).

Whatever they were doing, they were rudely interrupted on 2 March, when the author effortlessly plucked the male from the crevice. One second, he's wallowing in the essence of Laura, the next, he's whisked into bright sunlight. The next thing the poor guy knew, he was being held in a vertical position by the ape-thing who grabbed him, while another ape-thing stuck him in the tail with a needle-sharp spine. *Ouch — the burn seemed to last an eternity.* And then all of a sudden there were many ape-things of both sexes, and the party was on him as he was endlessly passed from one set of hands to the next (Figure 12). From there, things only got worse. He was devoured by a cloth sack, and entered a form of purgatory that he could not even begin to understand. Following a long period of that, he entered a tiny and compressed world of new scents that were not like anything he had ever experienced. Then came the final horror. He was hefted from his

compressed world by the hands of an ape-thing, who stuffed his face into a soft but suffocating dead end of a Gila Hole, and he was overwhelmed with a vile fragrance. Eventually, the lights went out for him, and blessed sleep ensued. When he awakened, he was aware of acute pain toward his abdomen. While still groggy, he was thrust back into cream-colored purgatory for a long while, until he was suddenly whisked out and placed back on the ground just outside of Laura's crevice. Now he was back in his world, as well as mine. On 7 March, at 1412 hours, I wrote the following words about his release day. "Hs2 still at site #34 (solo)." Whatever disturbance to the HESU force occurred on the capture of our new male, it wasn't enough to drive Laura away. Gordon arrived later that day with her bagged boyfriend in hand. We hoofed our way up to Laura's Site #34 with him. My datasheet has this to say about what happened next: "Release at 1751, release photod x2, brief hesitation, right into crevice." His "abduction" was behind him (Figure 11, right). We will speak more of Hs5 (Hercules) next month.



Figure 12. And everybody was having fun except the Gila Monster! (Left to right): Mike Dreslik, Gordon Schuett (holding Laura's boyfriend, *Heloderma suspectum* #5 [Hs5] "Hercules"), Maggie Turnbull, Erika Nowak, Diane Hope, Ed Moll. 2 March 2002. See also Figure 11.

Gila Monster reproduction, from then to now and back to then again

The author finds it impossible to relay the story of Laura's spring and foresummer 2002 antics without including some degree of pontification about what we know now versus what we knew then. In 2002, *nobody* had ever documented wild mating with HESU in southern Arizona. All that we had to go with was Stephen Goldberg's landmark 1997 paper (Goldberg, 1997). The short and simple facts to emerge from this masterful work was that out of 57 preserved adult male Tucson-based HESU sampled from March through November, 20 out of 20 had their gonads loaded with sperm in May, as did 5 out of 8 in June. There was zero evidence of spermiogenesis occurring in the remaining 29 male HESU sampled in March, April, and July through November. If this was not enough of a sample size to prove that May and June were *the* months that mating happened with HESU, I *still* hope we will *never* have more. Talk about abduction and 19 terrors! We now know that on 7 May 2007, Bill Radke was collecting HESU for processing in Cochise County, Arizona. He had an adult male in a bucket, and a few hours later, he dropped an adult female in with him. Within a matter of seconds, the male began copulation! (Radke, pers. comm.) Finally, on 17 May of 2014, Erin Zylstra photographed an attempted mating episode at Saguaro National Park in Pima County, Arizona (Zylstra et al., 2015).

So, we have a pretty good idea that HESU near Tucson mate in May. There is an abundance of information that points toward HESU laying their eggs from late June through mid-August, and Dale DeNardo was discovering that early July was prime time for nesting with his HESU study three miles south of ours (DeNardo, 2018). Goldberg (1997) suggests that at least in his sample, long-term sperm storage was not present. Hence, HESU likely mate locally in May, and females likely oviposit in early July, roughly setting up a 60-day conception-to-egg scenario. Those who breed HESU tell us that hatching occurs after somewhere around 130 days. There was *never* a reason to doubt this was happening in the wild, except for the fact that the young do not appear on the landscape until the following May at the earliest. The May emergence of young HESU upon the landscape is well-known to even the most hack local herper, yet the phenomenon of eggs laid in July not producing visible results until the following May did not make sense to the finest minds in herpetology for decades. It was not until late October of 2016 that a construction crew unearthed a nest containing five eggs in the process of hatching that the first ray of proof regarding when HESU eggs hatch was delivered (Repp, 2017; DeNardo et al., 2018).

Laura's spring to foresummer 2002

Laura's boyfriend, Hs5 (Hercules), left her by 11 March. At the time, I thought it was us and our 19 terrors that caused him to leave. While it would be truly stupid to suggest all of that was not a factor, we later learned that males routinely visit and leave females in the dead of winter (Schuett and Repp, unpublished data). Laura was not with Hercules or any other male that we knew of throughout the year 2002. But since we spent all of half hour per week with her at most, and she was not visible more than half of *that* time, we missed far more than what we saw with



Figure 13. Our first good look at Laura for 2002 occurred on 23 March. She had moved from the top of Iron Mine Hill well out onto the bajada, and was looking *great*!

her. Captive observations indicate that actual mating process takes roughly 2.5 hours (Schwandt, 2019). Laura had plenty of time to mate unseen by us, and she was not one to kiss and tell!

What we *do* know about Laura was that on 23 March 2002, she was viewed prowling a rodent run. She was all the way off the hill, and looking *great*! (Figure 13). And on 29 March she was back on the hill again—in her exact spot of capture from 1 April 2001. Site #1 fidelity! By 7 April, she had ping-ponged back to her overwintering Site #34 again. She led us to two fascinating places on 21 April, one of those rare days when she was tracked twice. The first was the location of the very first HESU that I ever saw on Iron Mine Hill. That had happened in February of 1999, and in those days of hands-off herping a barrage of HESU and tortoise sightings occurred at this site for over two years after. It is possible to likely that Laura—who was not yet Laura—was also part of the fun. Getting back to 21 April, between 1511 and 1813 hours, she slipped 100 meters upslope, and disappeared into the site that would one day become the gathering spot for 14 different HESU. My first description of our “communal hole” went thusly: “Not visible, signal ~1.4 meters deep beneath flat, shale-like gneiss boulder that is 200mm thick by 1m wide by 1.5m long. A 270 degree west-facing elliptical hole that is 100mm tall by 200mm wide plunges beneath this boulder and forms a chamber beneath” (Figure 14). The most interesting aspect of this day was that it



Figure 14. On 21 April 2002, Laura led us to this flat boulder. By the end of the study, *fourteen* different HESU had used this site. For this reason, we called it “the communal site.”

was the beginning of solving a three-plus-year mystery for me. She starts her day entering the site of my one “known” Gila Monster from 1999. She finishes her day in what was going to be her overwintering site of 2002–2003. And in January of 2003, my “known” HESU from 1999 was viewed and later captured here. (He became Hs7, “Frank.”) This sets up the possibility that the future Frank was in both places with her on 21 April 2002. It is not a stretch at all to be thinking this way. While we never “saw” Laura with a male in the spring of 2002, later events suggest she was with *at least one*.

Speaking of later events, on 27 April, Gordon and I saw her on open ground. We were so awestruck by the girth of her “pet store/Cuban cigar tail” that we captured and processed her. Her mass was a hefty 514 grams. The last we saw of her for a very long time was at 1727 hours on 24 May. Thankfully, we had the good sense to get a quick mass on her again. She was now an astounding 586 grams, having gained 72 grams in less than one month.

“It’s like tracking an effing Russian sub,” or, “Hi Laura—long time, no see . . .”

From 24 May to 15 July, we did not get a single visual on Laura. By 1 June at 1949 hours, she slipped unseen into her Site #45. My description of this site is as follows: “Hs2 not visible, buried beneath soft-soiled berm on north side of mini wash. [Added note: The mini-wash was ‘Laura’s Wash.’] A 3.2 meter tall white thorn acacia towers above the strongest signal. 2 loaf of bread type holes here, one is 2m north of signal, the other is 2m east of it, both lead to her potential chamber. Creosote dominates this site, ragweed and bursage nearby. Flagging in acacia directly above signal.” (Gila Holes often start as “loaf of bread” holes. They are shaped in such fashion as one could stuff a loaf of bread inside of them. They usually tighten up into Gila Holes at a depth of about 30 cm). I tracked her at Site #45 a total of seven times from 1 June to 25 June. She remained there, exactly beneath the flagging, for this entire time duration. She was not visible with every hit, but the signal told us exactly where she was.

She left Site #45 at some point after 25 June at 2135 hours, and entered Site #46 at some point before 0626 hours on 30 June. She had traveled almost exactly 500 m due east, unseen of

course, to get from Site #45 to Site #46. The description for Site #46 as written on 30 June of 2002 is as follows:

Hs2 not visible, signal from under NE edge of prickly pear, on wash island in channel of Suizo Wash. Prickly pear stands up to 2.5m tall, and is ~3m in diameter. A 4-meter-tall ironwood is among the prickly pear, and a 3m tall buckhorn cholla stands on east edge of same. A very old Neotoma midden is in the center of the prickly pear, entrances to midden exist in all directions. Soil is soft. Flagging to Ironwood above signal.

She remained not visible at Site #46, once again *exactly* under my flagging, from 30 June at 0626 hours to 13 July at 1915 hours. I tracked her a total of eight sporadically-timed visits during her stay here.

Finally, on 15 July at 2058 hours, Laura—or what was left of her—was viewed on open ground a scant 6 meters south of Site #46. How I wish that I had photographed the moment, but alas, I did not. I snagged and bagged her instead, and took her home to process her. Her mass was 325 grams, indicating that she had lost 261 grams since 24 May (Figure 15). Unbeknownst to me, she was about to lose about 30 more, for she was still carrying an infertile egg in her oviduct. Just after processing her, I whipped her up 59 grams worth of egg, which she greedily consumed. I still did not think to photograph her until 18 July, when I gave her to Schuett for a new transmitter surgery. As soon as the good Dr. Schuett got her home, he also stuffed her with another 50-plus grams of egg. And on 20 July, she passed that infertile egg discussed a few sentences back (Figure 16). This late-developing “slug” was the final proof that we needed to deduce that Laura had recently oviposited. We had our wild Gila Monster nest! All that remained to be done was to dig it up, and become famous. Nuthin’ to it!

On 28 July 2001, the good Dr. Schuett handed me Laura’s slug. I still have it today, preserved in 200-proof ethyl alcohol, and displayed in a prominent location in my office. When Gordon gave me this treasure, he made a rather cryptic statement. “One for mamma” said he. Indeed, and why not? Was this slug a self-generated reward for a famished egg-eating mother HESU like Laura? This author thinks so! What is it that keeps a starving HESU like Laura from eating her own eggs? Knowledgeable others feel that further hypothesis-driven science is required in order to keep egg off my own face with any premature proclamations. I am told by the finest HESU physiological minds that



Figure 15. Laura before and after oviposition. (Left) 27 April 2002. (Right) 18 July 2002. She lost a total of 261 grams of mass that we know of during the nesting process. (We did not see her between 24 May and 15 July 2002.)



Figure 16. On 20 July 2002, Laura passed an infertile egg, which Gordon collected for us. As neither of us had the good sense to photograph the slug, we borrow this image from Schwandt (2019: p. 127, fig. 165). The caption that goes with this photo is simple but adequate in documenting a little-understood behavior in Gila Monster reproduction: “About one week after egg laying, feces and an unfertilized egg (in the foreground) are passed together.”

it makes zero sense for a female to expend the resources and energy to develop an infertile egg merely to eat it. My own feeble arguments are based only on common sense and faith based on the premise that seeing is believing. Yes, female HESU often drop infertile eggs, one-to-two weeks *after* oviposition. Anybody who understands the nature of a famished HESU

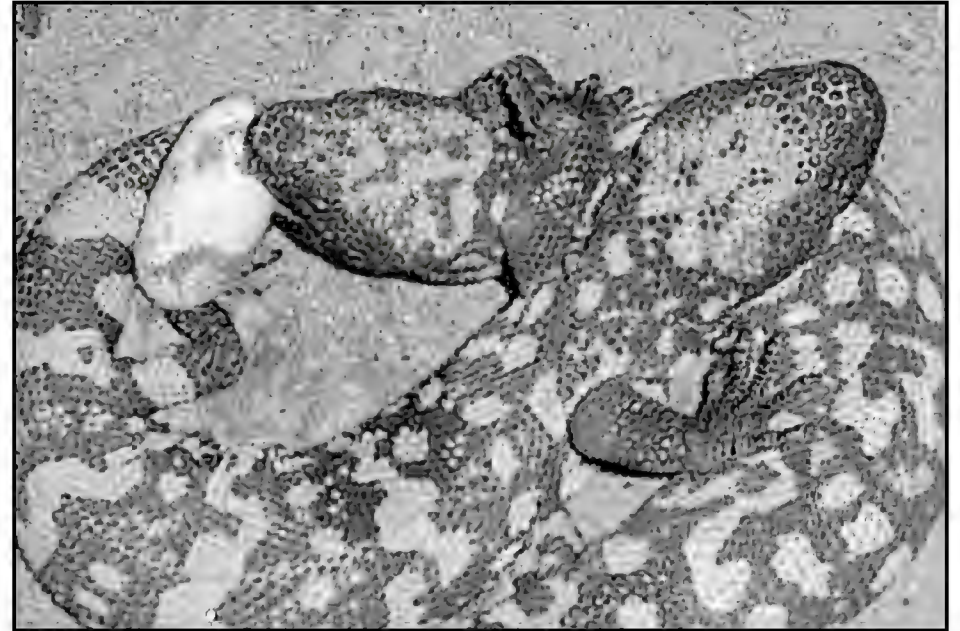


Figure 17. Team Schuett and Repp missed an opportunity to see if Laura would eat her own slug. But Schwandt (2019: p. 211, fig. 315) fills us in on what probably would have happened: “Female *Heloderma suspectum* eats her own late-deposited egg.”

knows that they will eat that egg! We simply can *not* write rules—physiological or otherwise—for creatures that neither read nor *obey* them! We close with an image from Schwandt (2019), and the caption that is beneath it (Figure 17).

Next month, we will speak more of Laura’s potential nest site, and describe more of the cool natural history aspects that she revealed to us. Until then:

This here is Roger Repp, signing off from Southern Arizona, where the turtles are strong, the snakes are handsome, and the lizards are above average.

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Herpetology 2022

In this column the editorial staff presents short abstracts of herpetological articles we have found of interest. This is not an attempt to summarize all of the research papers being published; it is an attempt to increase the reader's awareness of what herpetologists have been doing and publishing. The editor assumes full responsibility for any errors or misleading statements.

FOSSIL RELATIVE OF THE TUATARA DESCRIBED

T. R. Simões et al. [2022, Communications Biology 5(195):1-19] note that sphenodontian reptiles are an extremely old evolutionary lineage forming the closest relatives to squamates (lizards and snakes) and were globally distributed and more diverse than squamates during the first half of their evolutionary history. However, the majority of their fossils are highly fragmentary, especially within sphenodontines—the group including its single surviving species, *Sphenodon punctatus* (the tuatara of New Zealand)—thus severely hampering our understanding on the origins of the tuatara. The authors describe a new sphenodontian species (*Navajosphenodon sani*) from the Early Jurassic of North America (Arizona, USA) represented by a nearly complete articulated skeleton and dozens of upper and lower jaws forming the most complete ontogenetic series in the sphenodontian fossil record. CT-scanning provides plentitude of data that unambiguously place this new taxon as one of the earliest evolving and oldest known sphenodontines. Comparisons with *Sphenodon* reveal that fundamental patterns of mandibular ontogeny and skeletal architecture in *Sphenodon* may have originated at least ~190Mya. In combination with recent findings, these results suggest strong morphological stability and an ancient origin of the modern tuatara morphotype. The name of the new genus, *Navajosphenodon*, comes from a combination of “Navajo,” in honor of the native people from North America that inhabit the Colorado Plateau where the specimens were found, and “sphenodon,” in reference to the modern tuatara, *Sphenodon punctatus*. The species name *sani* is derived from a word in the Navajo language meaning “old age.”

DETECTING CRYPTIC FROGS

M. A. Schlaepfer et al. [2021, Journal of Herpetology 55(2):174-180] note that the protection of rare amphibians depends upon accurate information about their distributions, yet cryptic, low-density populations are easily missed during field surveys. The authors used sites with known populations of the U.S. federally threatened species *Rana chiricahuensis* (n = 34) and its congener *Rana yavapaiensis* (n = 11) in Arizona, to test whether a conspecific call stimulus can improve detectability of species. They show that the use of evoked vocal responses improves the detectability of initially silent anuran populations of *R. chiricahuensis* and *R. yavapaiensis* by 45% and 71%, respectively. Evoked vocal responses, however, were not strictly species specific: 19% of *R. chiricahuensis* and 45% of *R. yavapaiensis* populations also increased their vocal activity in response to hetero-specific stimuli. The low costs of the material (<50 USD per set) and the short time (1 min) to play a stimulus suggest that the additional costs associated with this technique will be minor relative to existing survey protocols. This technique offers the potential to improve the detection of other frog species, particularly in sites that are difficult to search visually, provided it is carried out by surveyors who can identify species by their calls.

INACTIVE TORTOISES

V. J. T. Loehr et al. [2021, Herpetologica 77(3):232-238] note that in arid regions with summer rainfall, herbivorous reptiles are able to acquire water and fresh food in the presence of high environmental temperatures that can promote ectotherm activity. However, extremely high temperatures and below average rainfall may also limit foraging opportunities due to risks of overheating and predation while gathering scarce food. Karoo dwarf tortoises (*Chersobius boulengeri*) inhabit an arid region in South Africa where most rains fall around austral summer (October–May). The authors used focal-animal observations and instantaneous recording to assess their behavioral patterns. Despite relatively high rainfall and available plant growth, Karoo dwarf tortoises spent approximately 80–90% of their time in retreats. Whereas activity (behavior outside retreats) in the spring was unrelated to time of the day, possibly due to moderate ambient temperatures, activity in the summer was restricted to the afternoon and evening, when tortoises walked and scanned for food and retreats, and fed only 11 min/d on average. In summer, body temperature of tortoises within retreats was positively associated with retreat temperatures, but tortoises appeared to thermoregulate using bodily postures and possibly other means. The authors suggest that Karoo dwarf tortoises mitigate predation risks by maintaining a low level of activity and thermoregulating within retreats. The short feeding time of Karoo dwarf tortoises compared to other tortoise taxa may result in slow growth and reproductive rates, which might in turn affect population resilience and conservation needs of this endangered species.

BLANDING'S TURTLE HATCHLINGS

M. Kastle et al. [2021, Journal of Herpetology 55(2):167-173] monitored survival and movements of Blanding's turtle (*Emydoidae blandingii*) hatchlings after natural (caged) and artificial incubation using radio-telemetry. Their purpose was to provide estimates of survival and to better understand the utility of alternative management tactics targeting this age class. The authors found that survival was similarly high (ca. 80% over 88 days) across treatments and study locations. Movement distances were similar among treatments but differed among study locations, perhaps because of differences in release site habitat variables. These results suggest that nest cages and artificial incubation are equally effective methods for increasing survival to hatching. Extrapolating from the 88 days of the study, until resumption of activity following hibernation, the authors found survival estimates of 40–78%, depending on the survival function used. When coupled with published rates of nest survival (6–41%) and hatch success (47–87%), anticipated age 0 survival, from egg deposition to emergence from hibernation, ranged from 1% to 28%. Although this analysis fills a knowledge gap in Blanding's turtle demography, further study is needed to improve the precision of survival estimates.

SPIDERS EATING SNAKES

M. Nyffeler and J. W. Gibbons [2021, *Journal of Arachnology* 49(1):1-27] document 319 incidents of snake predation by spiders, based on a comprehensive global literature and social media survey. Snake-catching spiders have been documented from all continents except Antarctica. Snake predation by spiders has been most frequently documented in USA (51% of all incidents) and Australia (29%). The captured snakes are predominantly small-sized with an average body length of 25.9 ± 1.3 cm (median = 27 cm; range: 5.8–100 cm). Altogether >90 snake species from seven families have been documented to be captured by >40 spider species from 11 families. About 60% of the reported incidents were attributable to theridiids (≈ 0.6 –1.1 cm body length), a spider family that uses strong tangle webs for prey capture. Especially the Australian redback spider (*Latrodectus hasselti* Thorell, 1870), the African button spider (*Latrodectus indistinctus* O. Pickard-Cambridge, 1904), an Israeli widow spider (*Latrodectus revivensis* Shulov, 1948), and four species of North American widow spiders (*Latrodectus geometricus* C. L. Koch, 1841, *Latrodectus hesperus* Chamberlin & Ivie, 1935, *Latrodectus mactans* (Fabricius, 1775), and *Latrodectus variolus* Walckenaer, 1837)—equipped with a very potent vertebrate-specific toxin (alatrotoxin)—have proven to be expert snake catchers. The use of vertebrates as a supplementary food source by spiders represents an opportunity to enlarge their food base, resulting in enhanced survival capability. Interestingly, the list of snakes captured by spiders also encompasses some species from the families Elapidae and Viperidae known to be highly toxic to humans and other vertebrates. Not only do spiders sometimes capture and kill snakes, quite often the tables are turned—that is, a larger number of arthropod-eating snake species (in particular nonvenomous species in the family Colubridae) include spiders in their diets.

DISTRIBUTION OF SUWANNEE ALLIGATOR SNAPPERS

K. E. Enge et al. [2021, *Chelonian Conservation and Biology* 20(2):184-199] note that the Suwannee alligator snapping turtle (*Macrochelys suwanniensis*) was first described in 2014. The species is thought to occur in blackwater and spring-fed streams of sufficient size throughout the Suwannee River drainage, but there exists limited detailed information regarding its range. To clarify the distribution of *M. suwanniensis*, the authors compiled 111 museum, 16 literature, and 40 other credible records. They also trapped streams throughout the Suwannee drainage in Georgia and Florida, plus 8 streams in the Big Bend region of Florida (total of 1893 trap nights). They documented the first records from the Willacoochee River and Okapilco, Piscola, Warrior, Jones, and Toms Creeks in Georgia and from Rocky and Olustee Creeks in Florida. Relative abundance based on catch per unit effort (CPUE) varied among streams (0.00–0.50) and sections of the same stream. *Macrochelys suwanniensis* is apparently scarce in the Okefenokee Swamp and in the Suwannee River upstream of White Springs, Florida (none trapped), but it occurs in small blackwater tributaries in this section of the river in both states. In the Suwannee River between White Springs and the estuary, the mean CPUE was 0.25,

and the highest trapping success in Florida was in downstream reaches of the Suwannee River and in its major tributaries, the Santa Fe and New Rivers. The species is widely distributed in Georgia, but relative abundance in most streams appears lower than in Florida. In Georgia, we had the highest trapping success in the Alapaha drainage and in sections of the Little River and Okapilco Creek in the Withlacoochee drainage. In Florida, the authors failed to trap *Macrochelys* in the purported distribution gap between the Suwannee and Ochlockonee drainages and in the Wacassassa River to the south, indicating that this species is restricted to the Suwannee drainage.

STRIKE SPEED IN WESTERN RATSNAKES

A. E. Burns and D. A. Penning [2021, *Journal of Herpetology* 55(1):55-61] note that prior to both offensive and defensive striking, snakes can display notable differences in prestrike behaviors between offensive and defensive contexts. However, few studies have investigated strike movements during the different scenarios with which snakes are faced. To better understand how snakes strike, the authors measured the strikes of western ratsnakes (*Pantherophis obsoletus*; $N = 11$) presented with two different targets: one simulated predator (a gloved human hand) and one prey (pre-killed mice). For each strike, they recorded strike distance, duration, velocity (average and peak), acceleration (average and peak), and time to start mouth gape. In both encounters, ratsnakes displayed similar time to the initiation of a mouth gape while all peak performances were significantly different between strike types, with performances being higher in defensive strikes. Defensive strikes took longer (mean = 122 ± 13 ms), reached greater distances (mean = 15.1 ± 1.7 cm), had higher maximum velocities (mean = 1.80 ± 0.11 ms⁻¹), and maximum accelerations (mean = 101.4 ± 15.2 ms⁻²). Offensive strikes had much shorter durations (mean = 49 ± 5 ms), distances (mean = 4.3 ± 0.6 cm), maximum velocities (mean = 1.06 ± 0.10 ms⁻¹), and maximum accelerations (mean = 81.4 ± 18.9 ms⁻²). The results for average performance measurements are similar to those for the maximum performance comparisons. These results show that snakes can recognize and differentiate prey from threats and respond differently in each situation. The results also show that predatory and defensive strikes are quantitatively and situationally distinct, should be treated as separate behaviors, and therefore should be evaluated and analyzed separately from one another.

HAWKSBILL TURTLES IN ANCHIALINE PONDS

N. J. Robinson et al. [2021, *Chelonian Conservation and Biology* 20(2):296-299] present four observations of hawksbill turtles, *Eretmochelys imbricata*, found in anchialine ponds on three islands in the Bahamas. Such ponds have no surface connection to the ocean, but are connected to it by subterranean passages. In at least one instance, the passage extended over 1.5 km in length. It is possible that the turtles were placed in these ponds by humans; however, it appears more likely that they accessed these habitats via the subterranean conduits, suggesting that anchialine ponds may function as either novel habitat or a potential ecological trap.

Minutes of the CHS Board Meeting, February 11, 2022

A virtual meeting of the CHS board of directors via Zoom conference video/call was called to order at 7:34 P.M. Board members Rachel Bladow, Stephanie Dochterman, Kyle Houlihan and Amelia Pollock were absent. Others in attendance were Zorina Banas and Jenny Hanson. Minutes of the January 14 board meeting were read and accepted with changes.

Officers' reports

Treasurer: Rich Crowley went over the January financial report.

Membership secretary: Mike Dloogatch read through the list of those whose memberships have expired.

Sergeant-at-arms: Tom Mikosz reported that 29 were in attendance at the January 26 virtual meeting.

Committee reports

Adoptions: Margaret Ann Paauw reported that we have been

receiving more adoption requests than relinquish requests, and more donations from the people adopting than the people relinquishing.

Old business

Margaret Ann Paauw, Jenny Hanson and Zorina Banas will work together to prepare an online poll of the membership, asking about the future direction of the CHS. There was discussion about the questions such a poll should include.

New business

Meetings in person or via zoom? The Notebaert Museum requires proof of vaccination. The board considered whether the February meeting should take place only via Zoom, or in person as well. The consensus favored in-person meetings.

The meeting adjourned at 9:11 P.M.

Respectfully submitted by recording secretary Gail Oomens

NEW CHS MEMBERS THIS MONTH

Rob Arlen
Alyssa Batista
Alexander Brand
Vince Losacco
Rebecca Sword

Advertisements

For sale: **highest quality frozen rodents**. I have been raising rodents for over 30 years and can supply you with the highest quality mice available in the U.S. These are always exceptionally clean and healthy with no urine odor or mixed in bedding. I feed these to my own reptile collection exclusively and so make sure they are the best available. All rodents are produced from my personal breeding colony and are fed exceptional high protein, low fat rodent diets; no dog food is ever used. Additionally, all mice are flash frozen and are separate in the bag, not frozen together. I also have ultra low shipping prices to most areas of the U.S. and can beat others shipping prices considerably. I specialize in the smaller mice sizes and currently have the following four sizes available: Small pink mice (1 day old—1 gm) , \$25 /100; Large pink mice (4 to 5 days old—2 to 3 gm), \$27.50 /100; Small fuzzy mice (7 to 8 days old—5 to 6 gm), \$30/100; Large fuzzy mice / hoppers (10 to 12 days old—8 to 10 gm), \$35/100 Contact Kelly Haller at 785-224-7291 or by e-mail at kelhal56@hotmail.com

For Sale: Now is the perfect time to get your copy of Midwest Partners in Amphibian and Reptile Conservation's *Field Guide to Amphibian Eggs and Larvae of the Western Great Lakes*. This pocket field guide was created to assist with identifying the eggs and larvae of 23 species of amphibians found in the Great Lakes watershed. The guide includes a key and each species description includes full color photos of adults, eggs, and larvae. Price is \$30.50, including shipping; \$25 for local pick-up (in Chicago only, contact parcmidwest@gmail.com to coordinate pick-up at Shedd Aquarium). Purchase at: <https://mwparc.square.site/>

Line ads in this publication are run free for CHS members — \$2 per line for nonmembers. Any ad may be refused at the discretion of the Editor. Submit ads to mdloogatch@chicagoherp.org.

UPCOMING MEETINGS

Please try to join us *in person* or online for the next meeting of the Chicago Herpetological Society, to be held at 7:30 P.M., Wednesday, March 30, at the Peggy Notebaert Nature Museum, Cannon Drive and Fullerton Parkway, in Chicago. The program for this meeting had not been confirmed at the time of this writing.

Jeff Coleman will be the speaker at the April 27 meeting. Jeff was awarded a CHS grant in 2021 to study how poison dart frogs acquired their chemical defense.

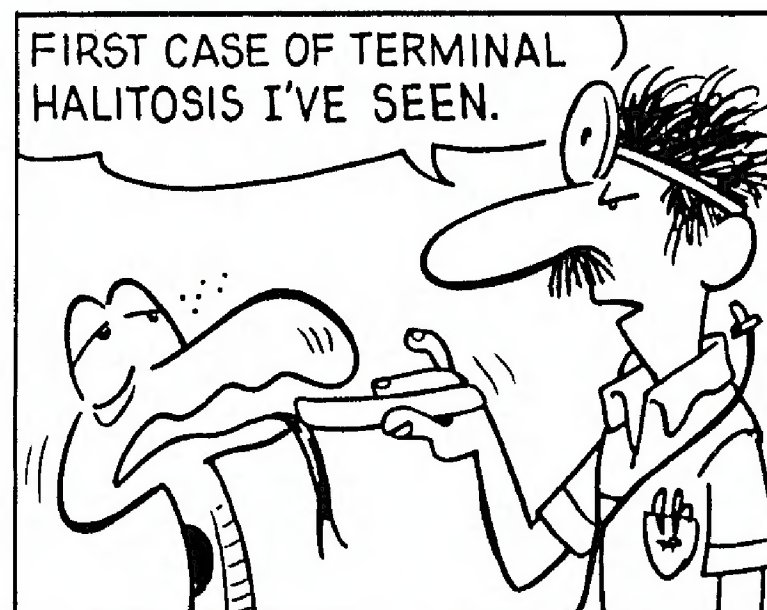
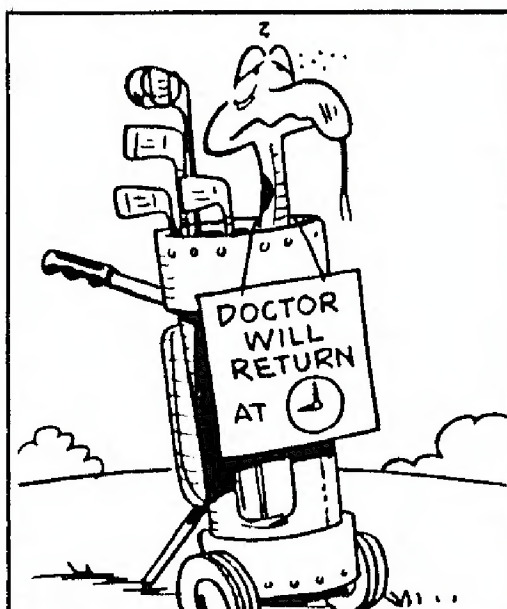
Please check the CHS website or Facebook page each month for information on the program. Information about attending a Zoom webinar can be found here:

<<https://support.zoom.us/hc/en-us/articles/115004954946-Joining-and-participating-in-a-webinar-attendee->>

Board of Directors Meeting

Are you interested in how the decisions are made that determine how the Chicago Herpetological Society runs? And would you like to have input into those decisions? The next board meeting will be held online. If you wish to take part, please email: mdloogatch@chicagoherp.org.

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